DEPARTMENT OF THE ARMY TECHNICAL MANUAL

DEPARTMENT OF THE AIR FORCE TECHNICAL ORDER

TM 11-2101
TO 31W2-1-28

BASIC MAINTENANCE PRACTICES

XY DIAL CENTRAL OFFICE EQUIPMENT

DEPARTMENTS OF THE ARMY AND THE AIR FORCE

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No. 11-2101
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AND THE AIR FORCE

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XY DIAL CENTRAL OFFICE EQUIPMENT (BASIC MAINTENANCE PRACTICES)

CHAPTER 1
INTRODUCTION

1. Scope

a. This manual covers the basic maintenance practices for XY dial central office equipment. The photographs, diagrams, and procedures are applicable to all Signal Corps XY dial central offices.

b. Forward comments on this manual direct to Commanding Officer, U. S. Army Signal Publications Agency, Fort Monmouth, N. J.

2. XY Equipment Coverage

a. This manual is one of a series on XY dial central office equipment. Other phases are covered in the following publications.

(1) TM 11–2116, XY Dial Central Office Equipment (Switching Circuits).

(2) TM 11–2117, XY Dial Central Office Equipment (Attendant's Switchboard and Information Desk).

(3) The publication covering XY Dial Central Office Equipment (Power, Ringing, and Supervisory Equipment).

(4) TM 11–2119, XY Dial Central Office Equipment (Test Desk, Testing Unit and Testing Techniques).

(5) TM 11–2120, XY Dial Central Office Equipment (Tools and Testing Equipment).

b. Information covering the XY distributing frames is contained in TM 11–2109, Distributing Frames and Line and Trunk Assignments, Step-by-Step Dial Central Office Equipment.

c. Information covering the current flow test set used for XY equipment is contained in TM 11–2112, Current-Flow Test Set, Step-by-Step Dial Central Office Equipment.

CHAPTER 2
TRUNKING

Section I. TYPES OF EXCHANGES AND DIAGRAMS USED

Note. This section includes a brief summary of various sizes of XY dial central offices, associated diagrams and records used. For additional details concerning specific sizes of offices, refer to the appropriate technical manuals (par. 2).

3. 50-Line Private Exchange (fig. 1)

A 50-line private exchange is a two-digit central office containing switching circuits necessary to initiate and complete station-to-station calls through the exchange. It does not provide any trunk circuits. The operation of the switching circuits is described in *a* through *c* below. Assume that a telephone user (calling party) at telephone No. 17 wishes to call telephone No. 48 (called party). When the handset of the calling party is lifted from the cradle, the following occurs:

a. The line relay associated with line 17 starts the operation of the allotter B relays, which operate the preselected linefinder (in this case, linefinder No. 1). The line relay also marks the calling party busy to incoming calls at the multipled connector bank contacts. The linefinder moves 1 step in the X direction and 7 steps in the Y direction to find the calling line. The linefinder then automatically extends the calling line through to the connector (in this case, connector No. 1), which is linked to linefinder No. 1. The connector returns dial tone to signal the calling party that the digits of the party to be called may now be dialed.

b. When the digits 4 and 8 of the called party are dialed, the connector operates in response to the pulses from the calling party's dial. The connector XY switch moves its wipers 4 steps in the X direction and 8 steps in the Y direction. The connection is now completed from calling telephone No. 17 to the called telephone No. 48.

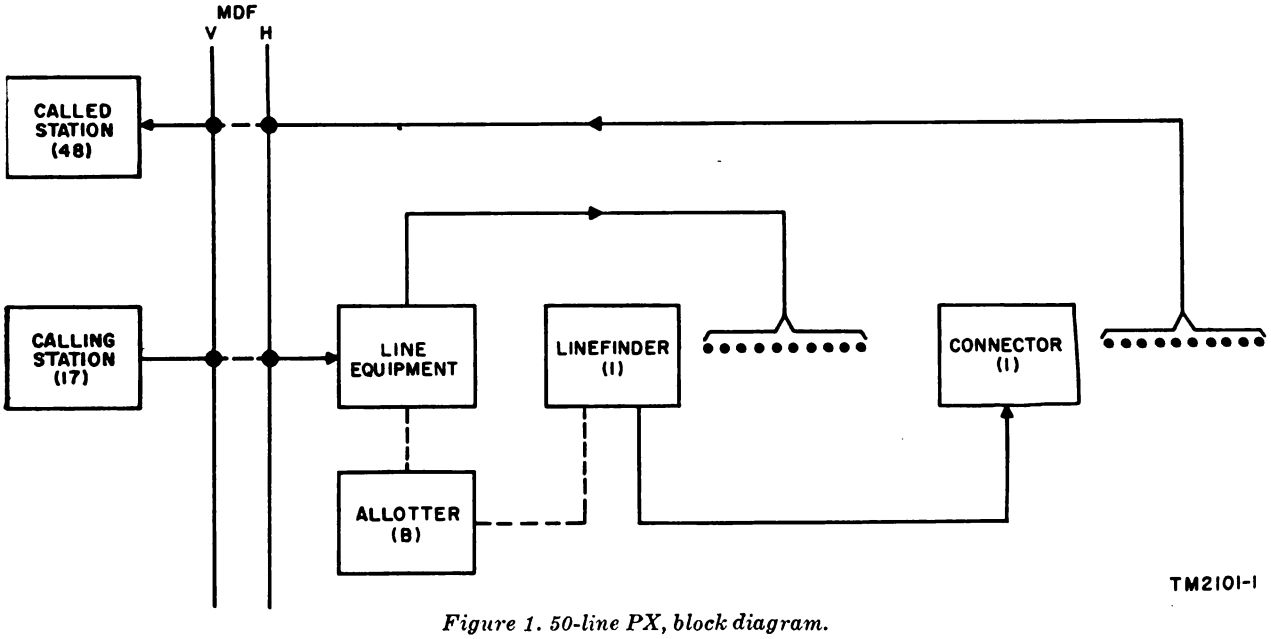

Figure 1. 50-line PX, block diagram.

If the called telephone is idle, the connector extends ringing current over the called line to operate the ringer in the called party's telephone. If the called party's line is busy, the connector transmits busy tone to the calling party's telephone.

c. When the called party answers, the connector disconnects the ringing current and interconnects the transmission path between the two telephones. When the telephone user replaces the handset on the cradle, the switching equipment releases, making the shared equipment (linefinder and connector) available for the next call.

4. 60-Line Private Branch Exchange (PBX) (fig. 2)

A 60-line PBX is a two-digit central office. It is similar to a 50-line private exchange (par. 3) except that it includes provisions for trunk circuits.

a. Outgoing Calls to Information Operator. Assume that a calling party at the PBX wishes to call the information operator at the parent office. When the dial tone is received from the connector, the calling party dials the digit 0, the connector XY switch steps 10 steps in the X direction, and then steps automatically in the Y direction until it finds an idle information trunk. The call is routed (by the trunk) to the parent office, where the information operator answers and completes the call.

b. Outgoing Call to Telephone User at Parent Office. The seizure of the two-way, dial-to-dial trunks for outgoing calls is the same as that described in *a* above, except that the calling party dials the digit 9 instead of 0. The connector XY switch finds an idle two-way dial-to-dial trunk which extends the call to the incoming selector at the parent office. The incoming selector supplies dial tone to the calling party at the PBX. The calling party then dials the number of the called station.

c. Incoming Calls From Parent Office. Assume that calling party at the parent office wishes to reach a station at the PBX. When the switching equipment at the parent office operates and seizes the two-way dial-to-dial trunk at the PBX, the trunk circuit operates the 9th level line equipment. The line equipment, allotter, and linefinder then operate as described in paragraph 3*a*. The connector at the PBX supplies dial tone to the calling party. When the calling party dials the called party's number, the connector interconnects the two stations as described in paragraph 3*b* and *c*.

5. 600-Line Central Office (fig. 3)

A 600-line central office may be a three- or four-digit central office containing the switching circuits necessary to initiate and complete station-to-station calls within the central office or between the exchange and a satellite office or another central office.

a. Station-to-Station Call.

(1) *Three-digit numbers.* Assume that a calling party at a telephone No. 475 wishes to call telephone No. 248 (called party). An idle linefinder hunts for and extends the calling line to the selector linked to that specific linefinder. The selector returns dial tone to the calling party, who then dials the digit 2 (the hundreds digit). The selector steps 2 steps in the X direction and hunts in the Y direction until it finds an idle connector in the 200 group. The connector extends the call as described in paragraph 3*b* and *c*.

(2) *Four-digit numbers (digit canceling).* All four-digit numbers in this typical office have the digit 3 as the first number of the telephone number. If the calling party wishes to reach a called party whose number contains four digits (for example, 3248), he proceeds as described in (1) above, except that the first digit dialed must be 3. When the digit 3 is dialed the selector moves 3 steps in the X direction and then automatically returns to normal (digit canceling). It is then stepped in response to the next digit dialed (in this instance, digit 2).

Note. The digit canceling feature applies *only* to the first digit dialed. Any level can be arranged as the digit canceling level.

b. Outgoing Call to Satellite Office. Assume that a calling party wishes to call a station at

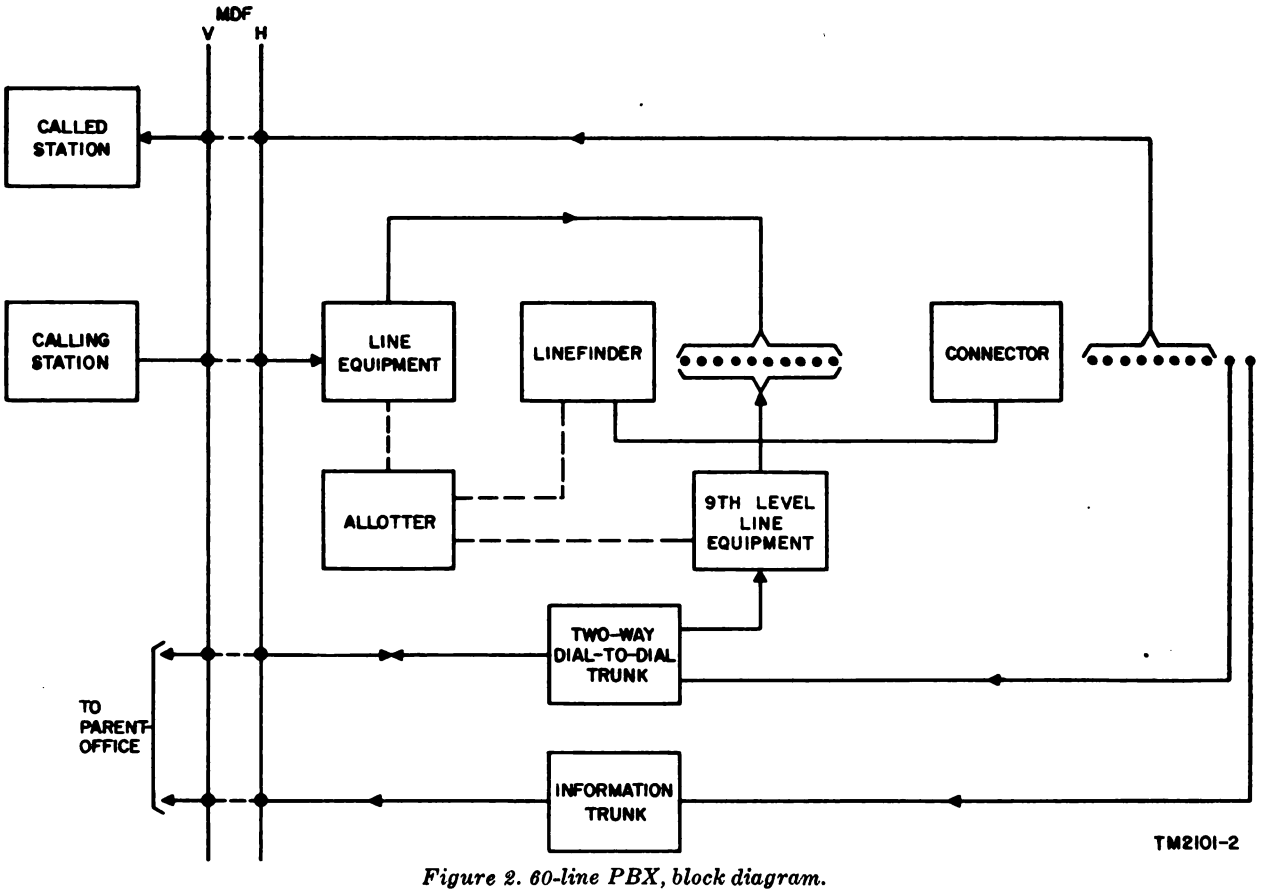

Figure 2. 60-line PBX, block diagram.

the satellite office. An idle linefinder extends the calling line to a selector which returns dial tone to the calling telephone. To reach the satellite office, the calling party dials the digit 8, causing the selector to step 8 steps in the X direction. The selector then automatically hunts in the Y direction until it finds an idle two-way dial-to-dial trunk. Seizure of the trunk circuit in turn, seizes the switching equipment at the satellite office. The calling party then dials the digit of the called number, causing the switching equipment in the satellite office to complete the connection.

c. Outgoing Calls to Commercial Central Office. An idle linefinder extends the calling line to selector which returns dial tone to the calling telephone. To reach the commercial central office, the calling party dials the appropriate digit (in this case, 9) causing the selector to step 9 steps in the X direction. The selector then hunts in the Y direction until it finds an idle combination trunk, which extends the call to the commercial office. Seizure of the combination trunk, in turn, seizes the switching equipment in the commercial office. The calling party then dials the digits of the called number, causing the switching equipment in the commercial office to complete the connection..

Note. If the commercial office is equipped with a manual switchboard, the combination trunk circuit signals the operator who completes the call.

d. Incoming Calls From Satellite Office. On incoming calls from a satellite office, the incoming selector is seized through the dial-to-dial trunk circuit associated with the trunk in use. The incoming selector steps in the X direction in response to the dial pulses and then hunts in the Y direction for an idle connector. (The banks of the incoming selectors are in multiple with the regular selector banks, thus making the local facilities accessible to the trunk circuits). When the calling party dials the last two digits, the connector extends the call as described in paragraph 3*b* and *c*.

e. Incoming Calls From Commercial Central Office. All incoming calls from a commercial

If the called telephone is idle, the connector extends ringing current over the called line to operate the ringer in the called party's telephone. If the called party's line is busy, the connector transmits busy tone to the calling party's telephone.

c. When the called party answers, the connector disconnects the ringing current and interconnects the transmission path between the two telephones. When the telephone user replaces the handset on the cradle, the switching equipment releases, making the shared equipment (linefinder and connector) available for the next call.

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A 60-line PBX is a two-digit central office. It is similar to a 50-line private exchange (par. 3) except that it includes provisions for trunk circuits.

a. Outgoing Calls to Information Operator. Assume that a calling party at the PBX wishes to call the information operator at the parent office. When the dial tone is received from the connector, the calling party dials the digit 0, the connector XY switch steps 10 steps in the X direction, and then steps automatically in the Y direction until it finds an idle information trunk. The call is routed (by the trunk) to the parent office, where the information operator answers and completes the call.

b. Outgoing Call to Telephone User at Parent Office. The seizure of the two-way, dial-to-dial trunks for outgoing calls is the same as that described in *a* above, except that the calling party dials the digit 9 instead of 0. The connector XY switch finds an idle two-way dial-to-dial trunk which extends the call to the incoming selector at the parent office. The incoming selector supplies dial tone to the calling party at the PBX. The calling party then dials the number of the called station.

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(2) *Four-digit numbers (digit canceling).* All four-digit numbers in this typical office have the digit 3 as the first number of the telephone number. If the calling party wishes to reach a called party whose number contains four digits (for example, 3248), he proceeds as described in (1) above, except that the first digit dialed must be 3. When the digit 3 is dialed the selector moves 3 steps in the X direction and then automatically returns to normal (digit canceling). It is then stepped in response to the next digit dialed (in this instance, digit 2).

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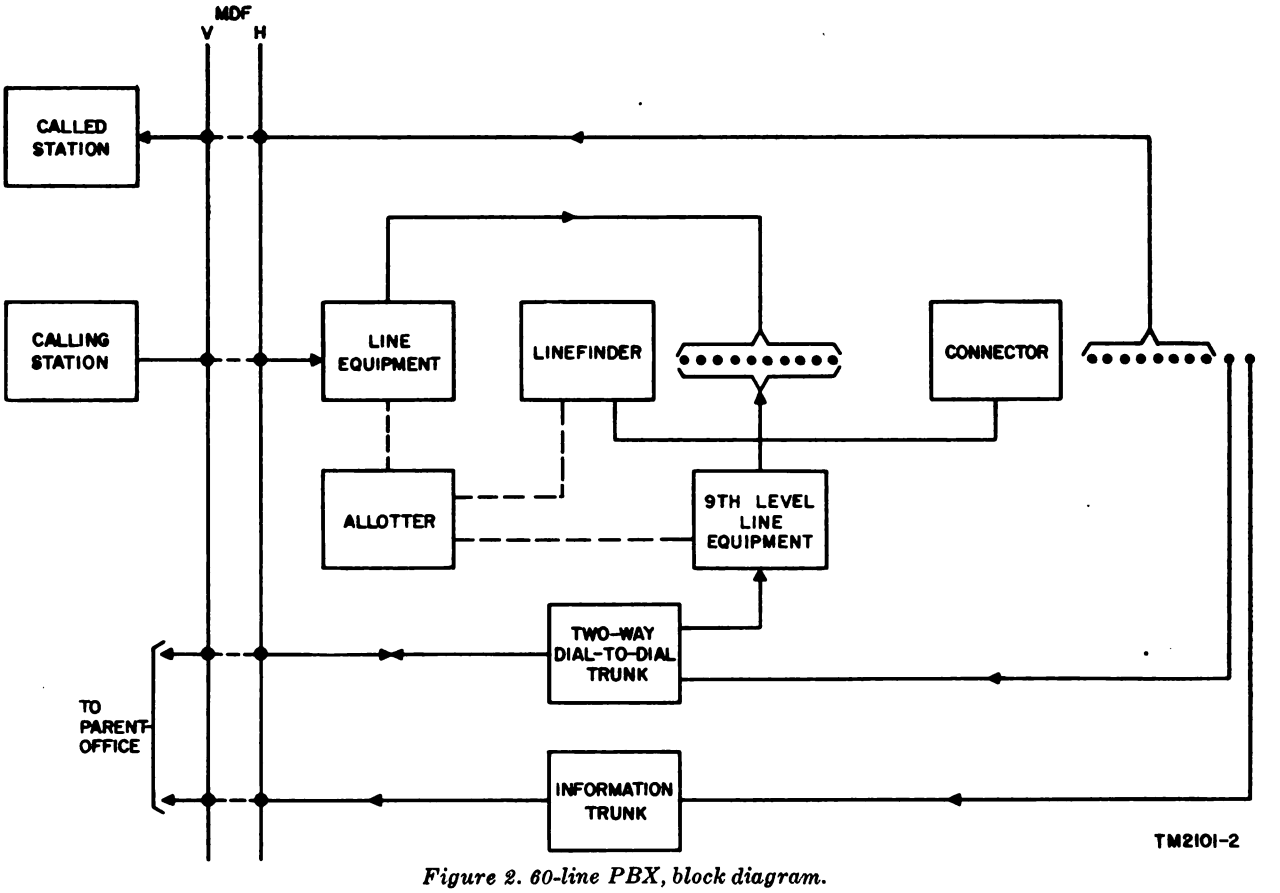


Figure 2. 60-line PBX, block diagram.

the satellite office. An idle linefinder extends the calling line to a selector which returns dial tone to the calling telephone. To reach the satellite office, the calling party dials the digit 8, causing the selector to step 8 steps in the X direction. The selector then automatically hunts in the Y direction until it finds an idle two-way dial-to-dial trunk. Seizure of the trunk circuit in turn, seizes the switching equipment at the satellite office. The calling party then dials the digit of the called number, causing the switching equipment in the satellite office to complete the connection.

c. Outgoing Calls to Commercial Central Office. An idle linefinder extends the calling line to selector which returns dial tone to the calling telephone. To reach the commercial central office, the calling party dials the appropriate digit (in this case, 9) causing the selector to step 9 steps in the X direction. The selector then hunts in the Y direction until it finds an idle combination trunk, which extends the call to the commercial office. Seizure of the combination trunk, in turn, seizes the switching equipment in the commercial office. The calling party then dials the digits of the called number, causing the switching equipment in the commercial office to complete the connection..

Note. If the commercial office is equipped with a manual switchboard, the combination trunk circuit signals the operator who completes the call.

d. Incoming Calls From Satellite Office. On incoming calls from a satellite office, the incoming selector is seized through the dial-to-dial trunk circuit associated with the trunk in use. The incoming selector steps in the X direction in response to the dial pulses and then hunts in the Y direction for an idle connector. (The banks of the incoming selectors are in multiple with the regular selector banks, thus making the local facilities accessible to the trunk circuits). When the calling party dials the last two digits, the connector extends the call as described in paragraph 3*b* and *c*.

e. Incoming Calls From Commercial Central Office. All incoming calls from a commercial

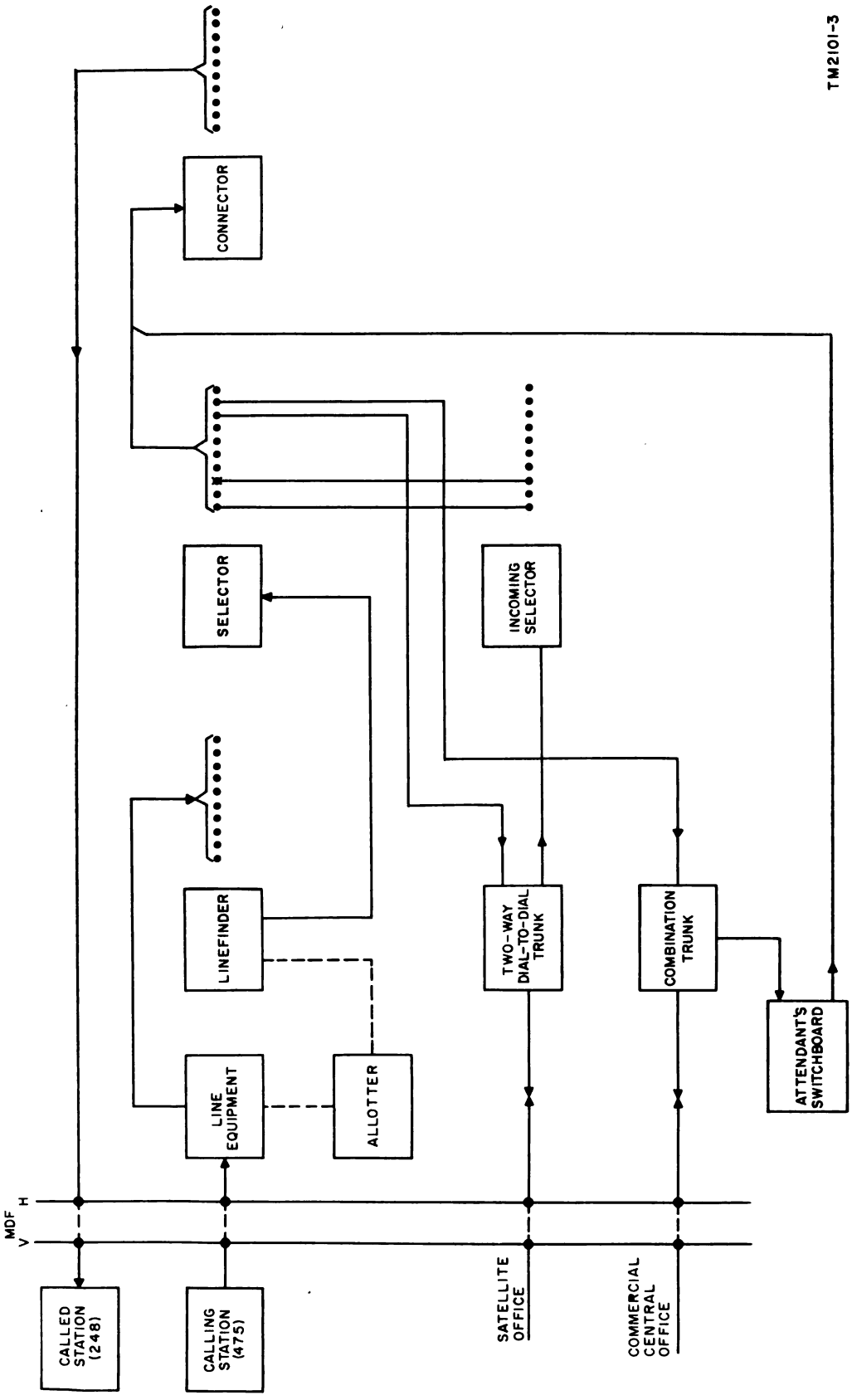


Figure 3. 600-line central office, block diagram.

central office are answered and extended to the called station by the operator at the attendant's switchboard. When the combination trunk is seized, from a commercial office the incoming line lamp on the switchboard lights and the operator inserts an answer cord plug into the jack associated with the trunk. When the operator answers, a transmission path is established between the calling party at the commercial office and the operator. The operator extends the call by inserting the call cord plug into an outdial-to-connector jack and dialing the last two digits of the called party's number. The connector then functions as described in paragraph 3*b* and *c*.

6. 5,000-Line Central Office (fig. 4)

A 5,000-line central office is a 4- or 5-digit central office capable of serving 5,000 individual stations. The 5,000-line central office operates in the same manner as the 600-line central office (par. 5) except that an additional rank of selectors is added to the switching equipment. The first selector extends the switching equipment to the second selector instead of the connector. Two two-way dial-to-dial trunk circuits are used, one for loops of 3,000-ohms or less, and one for loops of 2,000-ohms or less. Figure 4 is a block diagram of a typical 5,000-line central office as it is initially supplied. The diagram illustrates the switching circuits necessary for originating and completing a station-to-station call within the central office or between the 5,000-line central office and a satellite office or another central office.

a. If the digit 0 is dialed, the first selector will step to the tenth level and extend the call to the switchboard through the 0 level trunk circuit plate.

b. If the digit 9 is dialed, the first selector will step to the ninth level and extend the call through the combination trunk to the distant central office.

c. If the digit 7 or 8 is dialed, the first selector will step to the seventh or eighth level, extending the call to either the 3,000 ohms dial-to-dial or the 2,000 ohms dial-to-dial trunk respectively. The selected trunk will then extend the call to either of the satellite offices.

7. Trunking Diagram

Figure 5 is a typical XY dial central office trunking diagram for a 5,000-line central office. It shows the cabling arrangements between line and shared equipment; the trunking arrangement between equipments and outside facilities; and the connections to the attendant's switchboard, information desk, and wire chief's test desk. The diagram is used in conjunction with other central office records to trace calls within the central office, between the station lines and the main distributing frame (MDF) or between the attendant's switchboard, information desk, and wire chief's desk and the switching equipment and line equipment. The diagram is also used to determine the number (digits) which must be dialed to extend the call to a satellite office, central office, switchboard, information desk, wire chief's test desk, and other special switching equipment.

a. The blocks represent the various circuits and switches.

b. The 10 dots adjacent to a block represent the bank terminals that are engaged by the wipers of the XY switches.

c. The solid lines to and from the block show the actual interconnections between groups of equipment. The letters above the lines are the lead designations for the wires of each circuit.

d. Solid lines connecting the dots indicate multiple connections between bank terminals.

e. Dotted lines shown within the main distributing frame are used to designate the interconnections (jumpers) between interoffice or intra-office lines and the shared equipment. The dotted lines shown in the trunk distributing frame represent the interconnections between the attendant's switchboard, information desk, wire chief's test desk, and the shared equipment.

f. The dotted lines at the selector levels indicate future expansion of the central office.

g. The dots that are crossed (X) represent the drop back level (digit canceling).

8. Schematic Diagram

Schematic diagrams contained in the other publications of this series (par. 2) show the electrical circuit of a specific equipment. Relays,

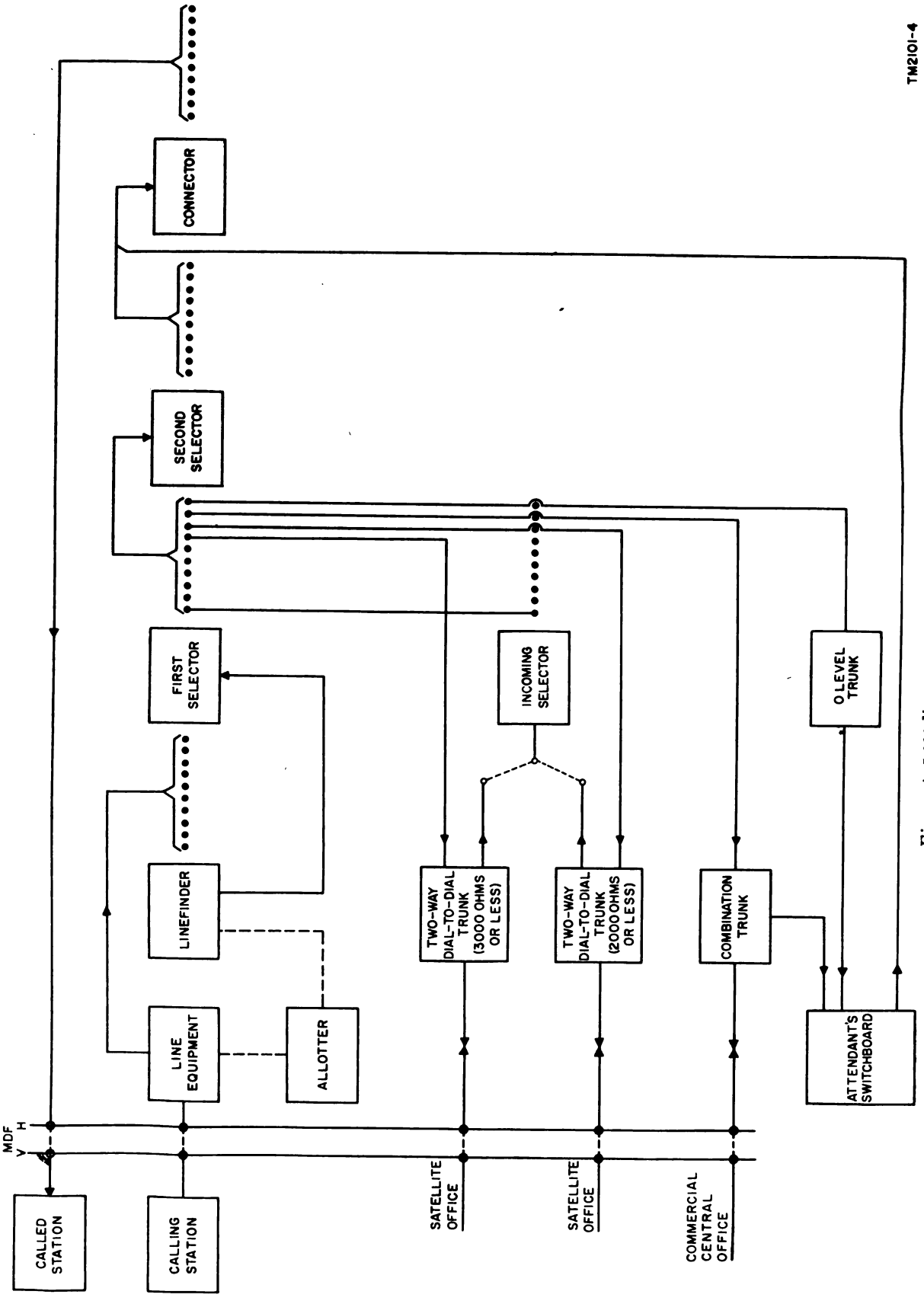
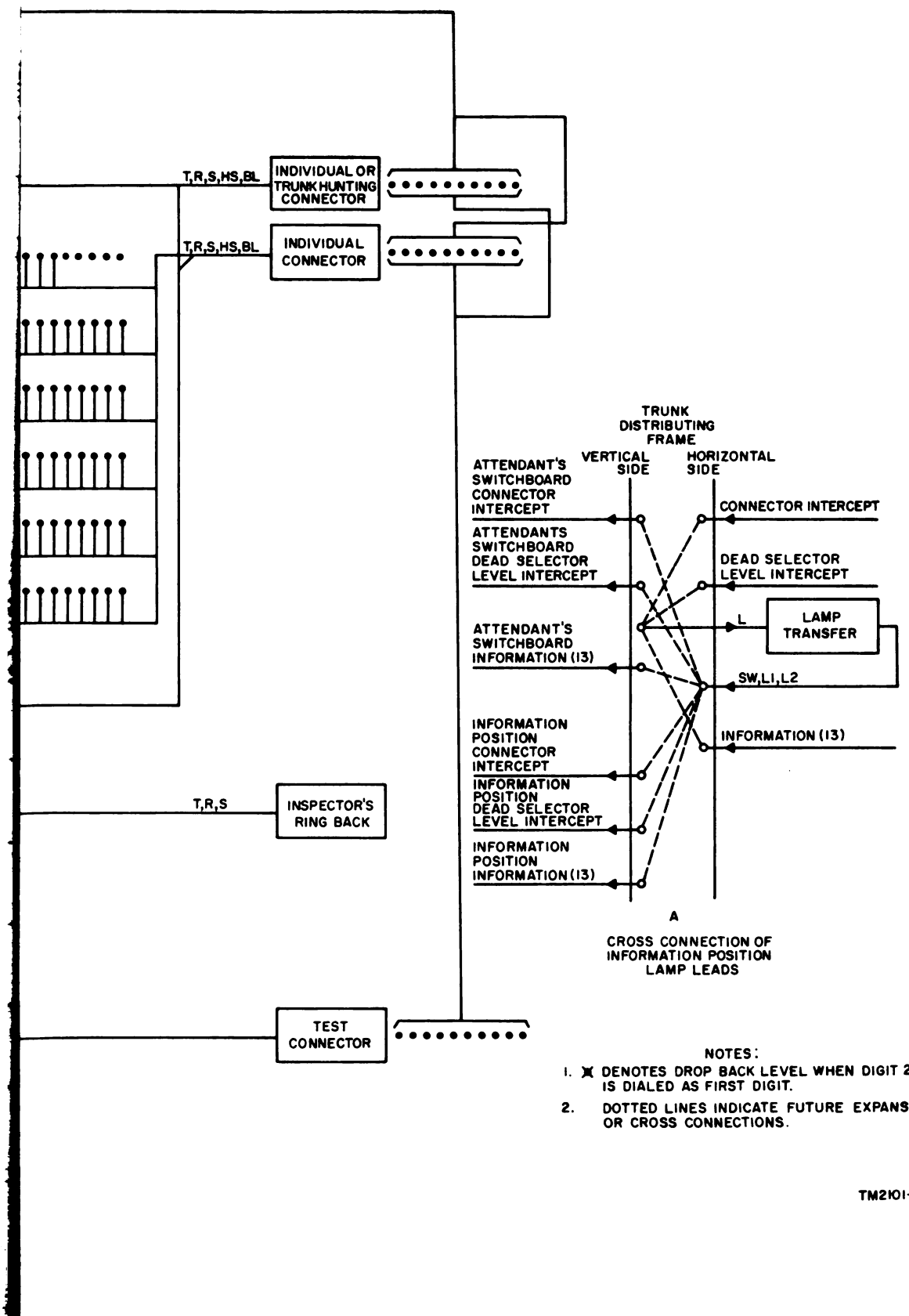


Figure 4. 5,000-line central office block diagram.



NOTES:

1. ✕ DENOTES DROP BACK LEVEL WHEN DIGIT 2 IS DIALED AS FIRST DIGIT.
2. DOTTED LINES INDICATE FUTURE EXPANSION OR CROSS CONNECTIONS.

TM2101-5

switches, resistors, capacitors, and other circuit apparatus are shown on these diagrams by symbols. Resistance and capacitance values for components are usually shown. Relay and switch contacts are numbered in order of their respective spring pileup. Variations in the connections for diffierent applications are covered by explanatory notes. Color coding for the wiring is not given.

9. Wiring Diagrams

Wiring diagrams contained in the other publications of this series (par. 2) show the actual wire, cable, or strap connections between items of equipment. Color coding for both manufacturer's and installer's wiring is shown, with the divisions indicated by notations on the drawing. In many cases, the gage of the wire for installer's wiring is specified. The actual points of connection are shown and identified by terminal designations.

10. Grading Terminal Assembly Drawings (fig. 6)

The grading terminal assembly (GTA) drawing provides detailed information about the circuits which appear on the selector banks. There is a GTA drawing for each rank of selectors in the exchange: first, second, special second, and third. The banks of all shelves of selectors of the same rank are extended to a GTA where all the levels of each shelf bank appear in single horizontal rows. This places each level of the entire rank of selectors in vertical alinement and simplifies the connection and multipling of circuits which must appear on the selector banks. For further details concerning grading terminal assemblies, refer to TM 11–2109.

a. Grading Terminal Assembly. The grading terminal assembly consists of 16 grading terminal boards, one for each bank of first selectors. Each of the boards consists of four terminals (T, R, S, and HS) for each of 10 positions in each of 10 levels for a total of 400 terminals. The selector levels are multipled (both straight and reversed) or strapped to cross-connect two or more selectors on a graded basis.

(1) *Straight multiple* means that the 10 contact sets in a particular level of a given selector shelf are connected to a corresponding contact set on the same level of another selector.

(2) *Reverse multiple* means that some or all of the 10 contact sets in a particular level of a given selector shelf are connected in a reverse order to the contact sets in the same level of another selector shelf.

(3) *Strapped multiple* means that some or all of the 10 contact sets in a particular level are connected together.

b. Selector Banks. Eight selector banks in bay 101 and eight in bay 102. Each selector bank is cabled to a grading panel board.

(1) The numbers in the rectangular boxes (rear B and front A) are the selector numbers.

(2) The blocks above the selector banks designated SW represent the supervisory circuit toggle switches.

c. Trunk Terminal Boards. There are 12 trunk terminal boards in each bay. The equipped positions are illustrated by a heavy line and the unequipped positions by a lighter line. The jumpers, tie cables, cable runs, and terminations are designated where applicable for each trunk group. For example, the trunk terminal board terminations 1–10 are connected to the first level, and the tie cables from these trunks are terminated in bay 103.

d. Tables. The tables provide the information necessary to determine the tie cable interconnections between the terminals on the trunk terminal board and the terminations in the bay (out to the next apparatus or circuit plate); and the jumper connections between the tie cable terminations and the outgoing trunk terminations. For example, terminals 1–20 are cabled to terminals 1–20 in bay 103; cable terminal 11 is jumpered to the bank or outgoing trunk terminal number 76.

11. Shelf Designation Cards

The shelf designation cards are used to identify the interconnections between circuits which comprise the switch trains (shared equipment) in the central office. Each card is furnished with standard information which enables tracing of calls through the central office. The cards are furnished for all shelves which

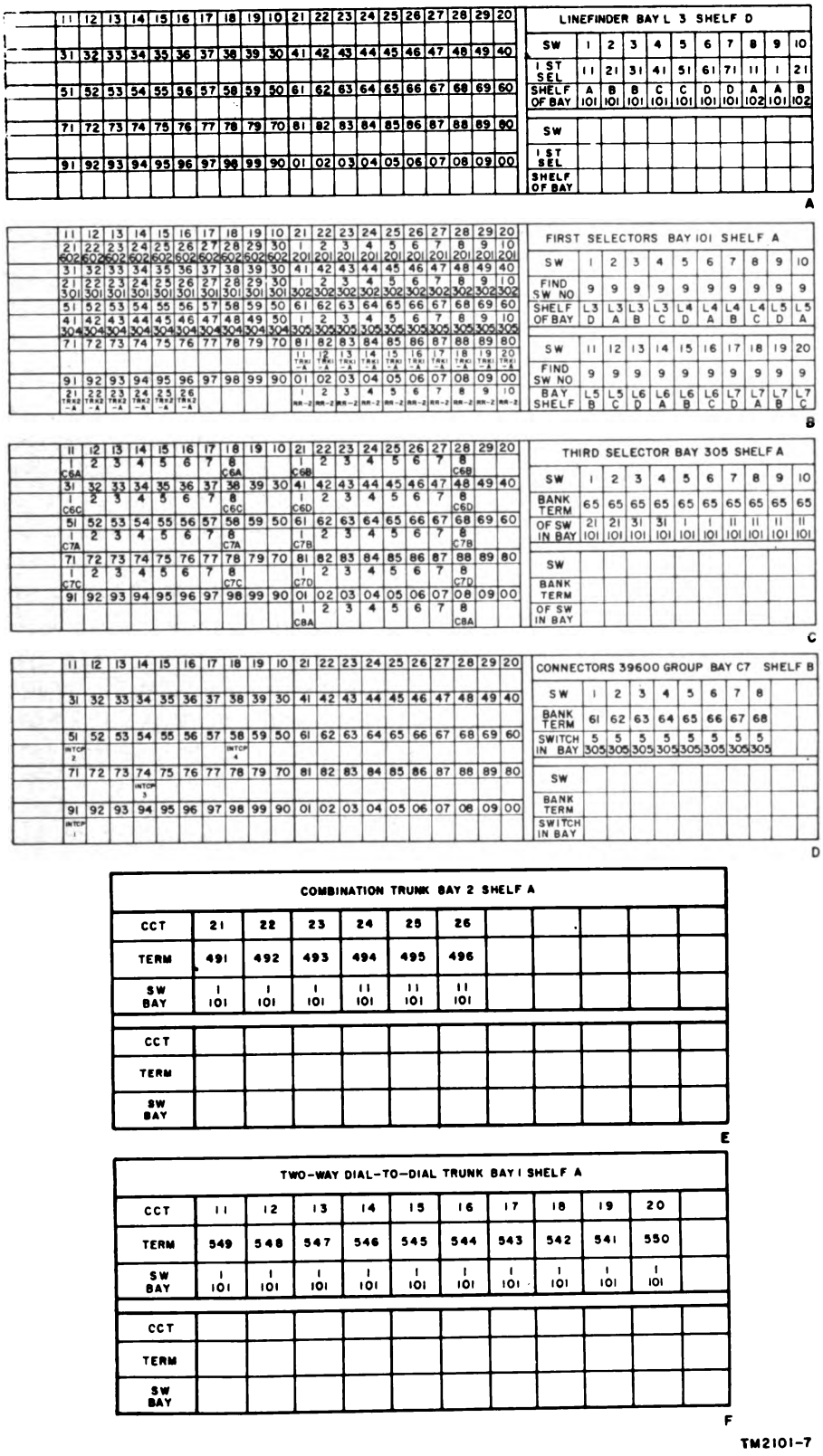


Figure 7. Shelf designation cards, 5,000-line central office.

mount the XY switches of the shared equipment and are on the inside of the switch cell door. The trunk cards are mounted on a bracket. The six shelf designation cards illustrated in figure 7 are typical for a 5,000-line central office.

a. Linefinder Shelf Designation Cards (A, fig. 7). Each linefinder shelf is provided with one shelf designation card. An explanation of the information given on the card is given below.

(1) The bay number and shelf letter of the linefinder are given in the title block.

(2) The linefinder switch associated with a particular first selector and the location of the selector are given on the right side of the card. For example, linefinder switch No. 9 is connected to first selector No. 1 located in shelf A, bay 101.

(3) The left side of the card (if used) provides a cross-reference of the connector bank terminals connected to the linefinder bank terminals at the MDF.

b. First Selector Shelf Designation Card (B, fig. 7). Each shelf of 20 first selectors requires one shelf designation card. An explanation of the information contained on the card is given below.

(1) The bay number and shelf letter of the first selector is given in the title block.

(2) The right side of the card is a cross-reference between the first selector switch and the linefinder switch. For example, first selector switch No. 1 is connected to linefinder switch No. 9 on bay L3, shelf D. The bay number and shelf letter correspond to these appearing on the title of the linefinder shelf designation card (A, fig. 7).

(3) The left side of the card (B, fig. 7) shows the equipment that is seized when any first selector in shelf A, bay 101 moves to a bank terminal. The card also gives the location of the forward equipment. For example—

(*a*) If a first selector steps in the X direction to level 6 and hunts to the fifth step in the Y direction, it seizes third selector switch No. 5, located in bay 305.

(*b*) If a first selector steps in the X direction to level 8 and hunts to the second step in the Y direction, it seizes trunk circuit No. 12 in bay TRK 1, shelf A.

c. Third Selector Shelf Designation Card (C, fig. 7). Each shelf of 20 third selectors requires one shelf designation card (C, fig. 7 shows first 10 switches only). An explanation of the information contained on the third selector shelf designation card is given below.

(1) The bay number and shelf letter of the third selector is given in the title block.

(2) The right side of the card is a cross-reference between the third selector and the first selector grading terminal assembly. For example, third selector switch No. 5 is connected to bank terminal 65 in bay 101. The first switch having access to this bank terminal is first selector No. 1 in bay 101.

(3) The left side of the card shows the connector switches that are seized when the third selector steps to a particular level and to a position in that level. For example, if third selector switch No. 5 steps in the X direction to level 6 and in the Y direction to position 8, the selector seizes connector No. 8 of bay C7, shelf B.

d. Connector Shelf Designation Card (D, fig. 7). Each connector shelf requires one shelf designation card. An explanation of the information contained on the connector shelf designation card is given below.

(1) The connector group number, bay number, and shelf letter are given in the title block.

(2) The right side of the card is a cross-reference between the connector and the third selector grading terminal assembly. For example, connector switch No. 8 is connected to bank terminal 68 in bay 305. The first switch having access to this trunk is third selector No. 5 in bay 305.

(3) The left side of the card shows the connector intercept circuits that are seized when the connector steps to 51,

58, 74, or 91. When the switch steps to any other bank terminals, the connector extends the call to a station line.

e. Trunk Shelf Designation Card. Each trunk shelf requires one shelf designation card. The information contained on the trunk shelf designation card is given below.

(1) *Combination trunk* (E, fig. 7).

(*a*) The combination trunk, the bay number, and the shelf letter are given in the title block.

(*b*) The columns provide a cross-reference between the trunk circuit number and the selector. For example, trunk circuit No. 21 is connected to 491 trunk number at the grading terminal assembly in bay 101. The first XY switch having access to this trunk is first selector No. 1 in bay 101.

(*c*) The trunk number (491) is used to determine which selector switches are in multiple with selector switch No. 1. This information can be obtained from the GTA drawings (fig. 6).

(2) *Two-way dial-to-dial trunk* (F, fig. 7).

(*a*) The two-way dial-to-dial trunk, the bay number, and shelf letter are given in the title.

(*b*) The columns provide a cross-reference between the trunk circuit number and the selector. For example, trunk circuit plate No. 11 is connected to terminal (trunk number) 549 at the grading terminal assembly in bay 101. The first XY switch having access to this trunk is first selector No. 1 in bay 101.

(*c*) The trunk number (549) is used to determine which selector switches are in multiple with selector switch No. 1. This information can be obtained from the GTA drawing (fig. 6).

12. Reading XY Switch

To determine the location of the bank contacts to which the XY switch has stepped, proceed as follows:

a. Figure 8 shows a typical XY switch in its offi-normal (operated) position. When the switch is operated, the notched flange moves to the right along the guide rule and stops next to a number located on the front of the guide rule. The level is determined by reading the digit on the guide rule in front of the notched flange.

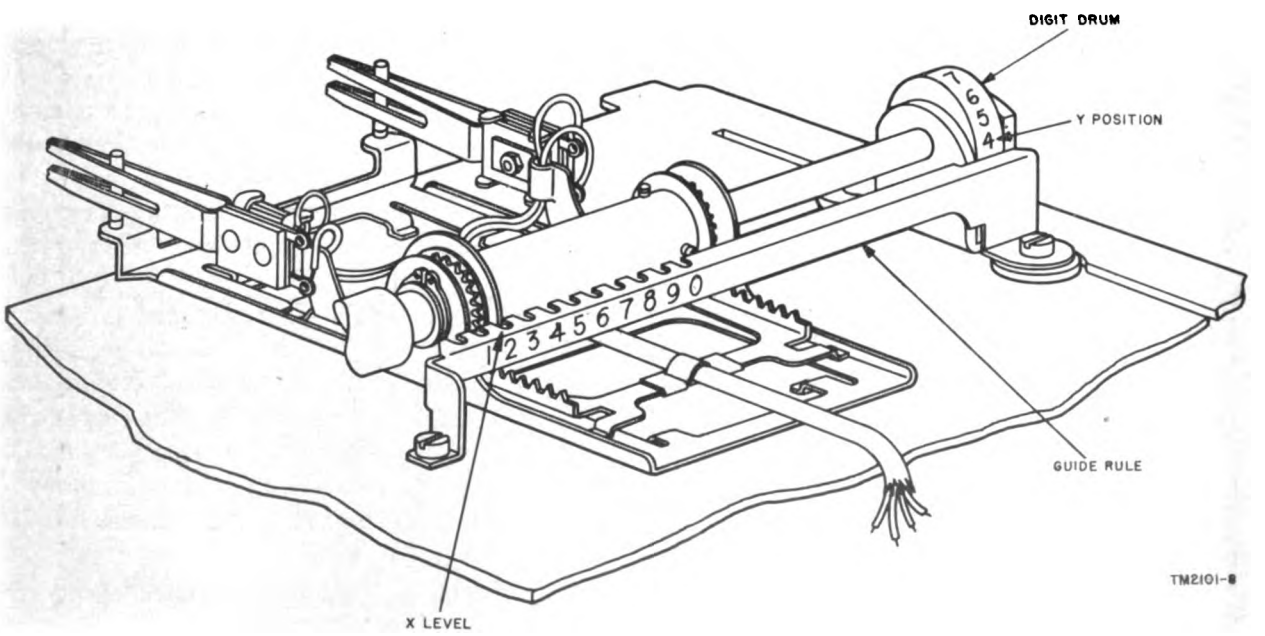


Figure 8. XY switch in position 24.

b. Once the X level has been reached, the switch operates in the Y direction. Y stepping occurs when the Y carriage moves into the wire bank associated with the XY switch. The digit drum rotates as the Y carriage moves to a position in the X level. The Y position is determined by reading the digit on the digit drum immediately above the guide rule.

Section II. CALL TRACING

13. General

Call tracing is a technique by which a call in progress can be followed through the shared equipment of the central office. To trace a call through the central office, either the calling party's number or the called party's number must be known. In addition, shelf designation cards, GTA drawings, and trunk designation cards should be used. Methods of tracing calls through a typical central office are given below.

14. Station-to-Station Calls, Tracing Forward (Calling Party's Telephone Number Known)

Assume that a calling party at telephone 26375 wishes to have a call traced to a called party within the central office.

a. Locate the 26300 group of linefinders and determine which linefinder has stepped to level 7, position 5.

b. Identify the linefinder. In this instance, it is linefinder No. 9 which is located in bay L3, shelf D (A, fig. 7).

c. Find linefinder switch No. 9 on the shelf designation card for linefinder bay L3 shelf D.

d. Determine the first selector which is connected to the linefinder. In this instance, it is linefinder switch No. 9 which is connected to first selector switch No. 1, which is located in bay 101, shelf A.

e. Locate first selector No. 1 in bay 101, shelf A.

f. Determine the level and position to which first selector No. 1 has stepped. In this instance, the switch has stepped to level 6 and hunted to position 5.

g. Determine from the first selector shelf designation card (B, fig. 7) which third selector is connected to bank terminal 65 of first selector No. 1. In this instance, the switch number of the third selector number is 5, located in bay 305.

h. Locate third selector No. 5 in bay 305, shelf A.

i. Determine the level and position to which third selector No. 5 has stepped. In this instance, the switch has stepped to level 6 and hunted to position 8.

j. Determine from the third selector shelf designation card (C, fig. 7) which connector is connected to bank terminal 68 of third selector No. 5. In this instance, the switch number of the connector is 8 located in bay C7, shelf B.

k. Locate connector No. 8 on bay C7, shelf B. This connector is in the 39600 group.

l. Determine the level and position to which connector No. 8 has stepped. If, for instance, the switch has stepped to level 7 and position 2, then the last two digits of the called party's number are 7 and 2. In this instance, 39672 is the called party's number.

15. Station-to-Station Calls, Tracing Backward (Called Party's Telephone Number Known)

Assume that a called party at telephone number 39672 wishes to have a call traced to a calling party.

a. Locate the 39600 group of connectors and find the connector switch which has stepped to level 7 and position 2. In this instance, the connector switch is 8.

b. Use the connector shelf designation card (D, fig. 7) to determine the third selector bank terminal linked to connector switch No. 8. In this instance, the card indicates that connector switch No. 8 is linked to bank terminals 68, and that selector switch No. 5 in bay 305 is the first choice switch for these bank terminals.

c. Locate third selector No. 5 in bay 305 and check to see if that selector has stepped to 68.

d. Assume that third selector switch No. 5 has stepped to 68. Use the third selector shelf designation card (C, fig. 7) to determine the first selector bank terminals linked to third se-

lector switch No. 5. In this instance, the card indicates that third selector switch No. 5 is linked to bank terminals 65, and that first selector No. 1 in bay 101 is the first choice switch for these bank terminals.

e. Locate selector No. 1 in bay 101, shelf A, and check to see if that selector has stepped to level 6, position 5.

f. If first selector switch No. 1 has not stepped to level 6, position 5 use the GTA drawing (fig. 6) to determine the other first selectors which are in multiple with switch No. 1. In this instance, first selector switches 2 through 40 in bay 101, or 1 through 40 in bay 102. Check to see which of the switches has stepped to 65.

g. Assume that first selector No. 8 has stepped to 65. Use the first selector shelf designation card (B, fig. 7) to determine which linefinder switch is connected to first selector switch No. 8. In this instance, it is connected to linefinder switch No. 9, located in bay L4, shelf C.

h. Locate linefinder switch No. 9 in bay L4, shelf C.

i. Identify the level and position to which the linefinder XY switch has stepped.

(1) The level and position of the linefinder XY switch are the last two digits of the calling party's telephone number.

(2) The first three digits (thousands and hundreds) correspond to the linefinder group in which the linefinder is contained. In this instance, the linefinder is located in the 26300 group. If the linefinder switch has stepped to 75, then the calling party's telephone number is 26375.

16. Tracing Trunk Calls

a. Combination Trunk Calls (Calling Party's Telephone Number Known). Assume that a calling party at telephone number 26375 originates a call to a distant central office via a combination trunk.

(1) *Tracing forward.*

(*a*) Trace the call from the calling station to the first selector as described in paragraph 14*a* through *e*.

(*b*) Determine the level and position to which the first selector has stepped.

(*c*) Assume that the first selector XY switch has stepped to level 9, position 2. This indicates that the call has been extended to another office via a combination trunk (fig. 5).

(*d*) Use the first selector shelf designation card (B, fig. 7) to determine which trunk has been seized. In this instance, the card shows that trunk circuit No. 22 in bay TRK 2, shelf A is linked to first selector No. 1 and has been seized by that selector.

(*e*) Use the wire chief's records to determine the terminals at the MDF associated with the trunk to the distant office from trunk circuit No. 22.

(2) *Tracing backward.*

(*a*) Determine the number of the trunk circuit in use by checking with the distant office.

(*b*) Use the wire chief's records to establish the number and location of the combination trunk circuit associated with the trunk in use.

(*c*) Assume that combination trunk No. 22 in bay TRK 2, shelf A has been seized.

(*d*) Locate the combination trunk circuit plate, then use the trunk designation card (E, fig. 7) to determine the trunk number between the first selector and the combination trunk circuit. In this instance, the trunk number is 492 and first selector No. 1 in bay 101 is the first choice switch for that trunk.

(*e*) Find the corresponding trunk number on the GTA drawing (fig. 6). Determine where first selector switch No. 1 is located. In this instance, the GTA drawing shows that the selector switch is located in shelf A and trunk No. 492 is on level 9 and position 2.

(*f*) Locate first selector switch No. 1 in bay 101, shelf A and check to see if it has stepped to level 9, position 2. If it has not, proceed with (*g*) below.

(*g*) Refer to the GTA drawing to determine which first selector banks are in multiple with shelf A.

1. Observe that first selectors 2 through 20 in shelf A on bay 101 are also linked to bank terminal 92.

2. Determine which of these first selectors has stepped to 92.

(*h*) Assume that first selector No. 11 of bay 101, shelf A, has stepped to 92. Use the first selector shelf designation card (B, fig. 7) to determine which linefinder is associated with that selector. In this instance, it is linefinder No. 9 in bay L5, shelf B.

(*i*) Locate linefinder No. 9 in bay L5 shelf B.

(*j*) Identify the level and position to which the linefinder switch has stepped.

1. The level and position of the linefinder switch are the last two digits of the calling party's telephone number.

2. The first three digits (thousands and hundreds) correspond to the linefinder group in which the linefinder is contained. In this instance, the linefinder is located in the 26300 group of linefinders. If the linefinder switch has stepped to 75, then the calling party's telephone number is 26375.

b. Combination Trunk Calls (Calling Party at Distant Office). No special procedure is required for tracing calls that originate at a distant office, since all incoming calls via combination trunks terminate at the attendant's switchboard. The operator at the switchboard can identify the number of the combination trunk by using the associated lamps and designation strips located at each positional unit. The exact location of the trunk circuit plate can then be determined from the wire chief's records.

c. Two-Way Dial-to-Dial Trunk Calls (Calling Party's Telephone Number Known). Assume that a calling party at telephone number 26375 originates a call to a distant office via a two-way dial-to-dial trunk.

(1) *Tracing forward.*

(*a*) Trace the call from the calling station to the first selector as described in paragraph 14*a* through *e* above.

(*b*) Determine the level and position to which the first selector has stepped.

(*c*) Assume that the first selector has stepped to level 8, position 8. This indicates that the call has been extended to a satellite office via a 2,000-ohm, two-way, dial-to-dial trunk (fig. 5).

(*d*) Use the first selector shelf designation card (B, fig. 7) to determine which trunk circuit has been seized. In this instance, trunk circuit No. 18 in bay TRK 1, shelf A is linked to the first selector.

(*e*) Use the wire chief's records to determine the terminals at the MDF associated with the trunk to the distant office from trunk circuit No. 18.

(2) *Tracing backward.*

(*a*) Determine the number of the trunk circuit in use by checking with the distant office.

(*b*) Use the wire chief's records to establish the number and location of the trunk circuit.

(*c*) Assume that trunk No. 12 in bay TRK 1, shelf A, has been seized.

(*d*) Locate the trunk circuit plate, then use the trunk designation card (F, fig. 7) to determine the trunk number between the first selector and the trunk circuit plate. In this instance, the trunk number is 548 and first selector No. 1 in bay 101 is the first choice switch for that trunk.

(*e*) Find the corresponding trunk number on the GTA drawing (fig. 6) and determine in which shelf first selector No. 1 is located. In this instance, the GTA drawing shows that the selector is located in shelf A and that trunk No. 548 is on level 8, position 8.

(*f*) Locate first selector No. 1 in bay 101, shelf A, and check to see if it has stepped to level 8, position 8. If it has not, proceed with (*g*) below.

(*g*) Refer back to the GTA drawing to determine which first selector banks are in multiple with switch No. 1.

1. Observe that all selectors in bays 101 and 102 are in multiple with selector switch No. 1.

2. Check to see if any switch (2–80) in bay 101 has stepped to 82. If it has not, proceed with *3* below.

3. Observe that there is a reversal of the first 9 trunks between shelves A and B of bays 101 and 102 and shelves C and D of bays 101 and 102. When checking shelves C and D of both bays, check for an XY switch that has stepped to 82. In all other shelves, check for an XY switch that has stepped to 88.

(*h*) Assume that first selector No. 1 of bay 101, shelf D has stepped to 82. Use the first selector shelf designation card (B, fig. 7) to determine which linefinder is associated with that selector. In this instance, the card shows that first selector No. 1 is linked to linefinder No. 9 in bay L3, shelf D.

(*i*) Locate linefinder No. 9 in bay L3, shelf D.

(*j*) To determine the calling party's telephone number, follow the procedure described in *a*(2) (*j*) above.

d. Two-way Dial-to-Dial Trunk Calls (Calling Party at Distant Office). Assume that a calling party at the distant satellite office originates a call.

(1) *Tracing forward.*

(*a*) Determine the number of the trunk circuit in use by checking with the distant office.

(*b*) Use the wire chief's records to establish the number and location of the trunk circuit associated with the trunk in use.

(*c*) Locate the trunk circuit plate; then use the trunk designation card (F, fig. 7) to determine the number and location of the incoming selector which is linked to that trunk circuit.

(*d*) Locate the incoming selector and determine the level and position to which it has stepped.

(*e*) Use the incoming selector shelf designation card to determine which third selector is linked to the incoming selector.

(*f*) Locate the third selector and determine the level and position to which it has stepped.

(*g*) Use the third selector shelf designation card to determine which connector is linked to the third selector.

(*h*) Locate the connector and determine the level and position to which it has stepped. The connector group identifies the first digits of the called party's number, and the level and position of the connector XY switch are the last two digits of the called party's telephone number.

(2) *Tracing backward.*

(*a*) Locate the connector group associated with the called party's telephone number.

(*b*) Determine which connector has stepped to the level and position corresponding to the last two digits of the called party's telephone number.

(*c*) Use the connector shelf designation card to determine which third selector switch is linked to that connector.

(*d*) Locate the third selector and determine the level and position to which it has stepped.

(*e*) Use the third selector designation card to determine which incoming selector is linked to the third selector.

(*f*) Locate the incoming selector and determine the level and position to which it has stepped.

(*g*) Use the incoming selector shelf designation card to determine the trunk circuit in use.

17. Tracing Attendant's Switchboard Calls

a. Information Trunk Calls. Assume that a calling party (26375) within the central office

wishes to have a call traced to the attendant's switchboard via an information trunk.

(1) *Tracing forward.*

(*a*) Trace the call from the calling party to the first selector as described in paragraph 14*a* through *e*.

(*b*) Determine the level and position of the first selector. In this instance, the first selector has stepped to level 1 and seized a special second selector to route the call to the attendant's switchboard.

(*c*) Use the first selector shelf designation card to establish which special second selector has been seized.

(*d*) Locate the special second selector and determine the level and position to which it has stepped.

(*e*) Use the special second selector shelf designation card to determine the information trunk circuit seized by the special second selector.

(*f*) Trace the call from the information trunk to the attendant's switchboard by using the wire chief's records and the designation strips on the positional unit.

(2) *Tracing backward.*

(*a*) Obtain from the operator the number of the information trunk circuit which has been seized by the call.

(*b*) Use the wire chief's records to locate the information trunk circuit plate.

(*c*) Use the information trunk designation card to determine the trunk number or its location on the bank terminals of the special second selector.

(*d*) Locate the special second selector (first choice) and determine the level and position to which it has stepped.

(*e*) Locate the first selector (first choice) linked to the special second selector.

(*f*) If the first selector (first choice) has not stepped to the level and position to correspond to that indicated on the special second selector shelf designation card, use the GTA drawing to determine which first selectors are in multiple (par. 10).

(*g*) When the first selector has been located, trace the call to the calling party by the procedure given in paragraph 15*g* through *i*.

b. O Level Trunk Calls. Assume that a calling party within the central office wishes to have a call traced to the attendant's switchboard via a O level trunk.

(1) *Tracing forward.*

(*a*) Trace the call from the calling party to the first selector as described in paragraph 14*a* through *e*.

(*b*) Determine the level and position to which the first selector has stepped. In this instance, the first selector has stepped to level O and seized a trunk to route the call to the attendant's switchboard (fig. 5).

(*c*) Use the first selector shelf designation card to establish which O level trunk is in use.

(*d*) Locate the O level trunk circuit plate which has been seized by the first selector.

(*e*) Trace the call from the O level trunk to the atendant's switchboard by using the wire chief's records and the designation strips at the positional unit.

(2) *Tracing backward.*

(*a*) Obtain from the operator the number of the O level trunk circuit plate which has been seized by the call.

(*b*) Use the wire chief's records to locate the O level trunk circuit plate.

(*c*) Use the O level trunk designation card to determine the trunk number or its location on the bank terminals of the first selector.

(*d*) Check to see whether the first selector (first choice) as indicated by the O level trunk designation card has stepped to the level and position of the trunk.

(*e*) If it has not, use the GTA drawing to determine the selectors which are in multiple (par. 10).

(*f*) When the first selector XY switch has been located, trace the call to the calling party by following

the procedure in paragraph 15*g* through *i*.

c. Fire Alarm Trunk Calls. Assume that a calling party (26375) within the central office wishes to have a call traced to the switchboard via a fire alarm trunk.

(1) *Tracing forward.*

(*a*) Trace the call from the calling party to the special second selector as described below.

1. Locate the 26300 group of linefinders and determine which linefinder has stepped to level 7, position 5.

2. Identify the linefinder. In this instance, linefinder No. 9 is located in bay L3, shelf D (A, fig. 7).

3. Find linefinder switch No. 9 on the shelf designation card for linefinder bay L3 shelf D.

4. Determine the first selector which is connected to the linefinder. In this instance, linefinder switch No. 9 is connected to first selector switch No. 1, which is located in bay 101, shelf A.

5. Locate first selector No. 1 in bay 101, shelf A.

6. Determine the level and position of the first selector. In this instance, the first selector XY switch has stepped to level 1 and seized a special second selector.

7. Use the first selector shelf designation card to establish which special second selector has been seized.

8. Locate the special second selector and determine the level and position to which it has stepped.

(*b*) Use the special second selector to determine the fire alarm trunk circuit plate seized by the special second selector.

(*c*) Trace the call from the fire alarm trunk to the attendant's switchboard by using the wire chief's records and the designation strips at the first positional unit.

(2) *Tracing backward.*

(*a*) Obtain from the operator the number of the fire alarm trunk which has been seized by the call.

(*b*) Use the wire chief's records to locate the fire alarm trunk circuit plate.

(*c*) Trace the call to the calling party by the procedure given below.

1. Use the information trunk designation card to determine the trunk number or its location on the bank terminal of the special second selector.

2. Locate the special second selector (first choice) and determine the level and position to which it has stepped.

3. Locate the first selector (first choice) linked to the special second selector.

4. If the first selector (first choice) has not stepped to the level and position to correspond to that indicated on the special second selector shelf designation card, use the GTA drawing to determine which first selectors are in multiple (par. 10).

5. When the first selector has been located, trace the call to the calling party by the procedure described in paragraph 15*g* through *i*.

d. Connector Intercept Trunk Calls. Assume that a calling party, who has dialed a disconnected number, wishes to have a call traced to the attendant's switchboard.

(1) *Tracing forward.*

(*a*) Trace the call from the calling station to the connector as described in paragraph 14*a* through *k*.

(*b*) Determine the level and position to which the connector has stepped.

(*c*) Use the connector shelf designation card (D, fig. 7) to determine the number and location of the connector intercept trunk linked to the connector.

(*d*) Trace the call from the connector intercept trunk to the attendant's switchboard by use of the wire chief's records and the designation strips at the positional unit.

(2) *Tracing backwards.*

(*a*) Obtain from the operator the number of the connector intercept trunk seized by the call.

(*b*) Use the wire chief's records to determine the bank appearance of the connector intercept trunk.

(*c*) Check to see which connector has stepped to the level and position of the connector intercept trunk.

(*d*) When the connector has been located, trace the call to the calling party by the procedure given in paragraph 15*b* through *i*.

Section III. TROUBLE SECTIONALIZATION

18. General

Trouble in XY dial central office equipment is first sectionalized to one of the four groupings of equipment described in *a* through *d* below. After the trouble has been sectionalized to one of the groups of equipment it is localized to a circuit within the group of equipment; then it is isolated to a component within the defective circuit.

a. Outside Equipment. This includes the telephone lines entering the central office and the external equipment associated with the telephone lines.

b. Line Circuits. This includes the line relays and the associated MDF.

c. Power, Ringing, and Supervisory Equipment. This includes the tone and ringing circuits, the alarm circuits, and the power distribution circuits.

d. Switching Circuits. These include the linefinders, allotters, selectors, connectors, and trunk circuits. The attendant's switchboard and information desk are also considered part of the switching circuits.

19. Sectionalization of Trouble to Outside Equipment

The first step in trouble sectionalization is to determine whether a particular trouble is due to outside equipment or inside equipment. To establish whether the outside or inside equipment is at fault, if not evident from the nature of the trouble, the suspected telephone or trunk line (including the equipment associated with the line) should be tested through the MDF by using the facilities of the test desk. The instructions for testing telephone and trunk lines are given in TM 11–2119. If the outside equipment is functioning properly, then the trouble is caused by the central office equipment.

20. Sectionalization of Trouble to Line and Trunk Circuits

If the trouble is in the central office equipment, the next step is to determine whether the trouble is caused by the line circuits and the associated MDF.

a. For troubles involving station lines, the line circuits should be tested. For troubles involving trunk lines from satellite offices, the two-way dial-to-dial trunk circuits should be tested. These tests should be performed by using the test desk as described in TM 11–2119.

b. Calls originating from another central office (via combination trunk circuits) or the common battery and local battery lines produce an appearance on the attendant's switchboard. The attendant at the switchboard can determine by inspection whether the trunk or common battery and magneto lines are functioning properly.

21. Sectionalization of Trouble to Common Supervisory Equipment

Troubles caused by the power, ringing and supervisory equipment are readily identified because the alarm circuits operate when failures occur in the power supply and in the tone and ringing equipment. In addition, power, ringing, and equipment troubles can be recognized because they produce multiple rather than individual troubles. Further sectionalization of troubles in the power, ringing, and supervisory equipment is described in the publication of this series covering power, ringing, and supervisory equipment.

22. Sectionalization of Trouble to Switching Circuits

After checking the outside equipment, the line and trunk circuits, and the power, ringing, and supervisory equipment for proper opera-

tion, trouble may be sectionalized to the switching circuits. Alarms are provided for serious troubles in the individual switching circuits. These alarms are classified as either power failures or equipment failures. A power failure alarm results when a fuse blows. An equipment alarm results when an XY switch fails to restore. Refer to TM 11–2116 for a description of these alarm circuits.

23. Trouble Localization Within Switching Circuits

a. General. To localize troubles in the switching circuits by call tracing, the calling party's and called party's numbers must be known. The wire chief or switchboard attendant should obtain maximum information about the reported trouble. A description of the reported trouble will permit the wire chief to determine the nature of the fault in most cases. After the initial determination has been made the wire chief should proceed to localize the trouble. After the trouble has been localized, refer to the troubleshooting charts, TM 11–2116, to isolate the trouble within the switching circuit.

b. Linefinder to Selector. To isolate a trouble, such as a no dial tone, which involves either a linefinder or first selector the approximate location of the fault must be known. In this instance, the trouble can be caused by a faulty linefinder, a faulty first selector, or the wiring between them. If the calling party has disconnected, follow the procedure below. If the calling party has not disconnected, proceed to (2) below.

(1) *Locating linefinder used by calling party.*

(*a*) Locate the group of linefinders which serves the calling party's telephone number.

(*b*) Operate the C switch of the hand test telephone and insert the test plug into the odd level jack if the telephone number of the calling party represents an odd level or into the even level jack if the telephone number represents an even level.

(*c*) Operate the R switch and release the C switch of the hand test telephone.

(*d*) Observe which linefinder is seized and listen for dial tone.

Note. The seized linefinder should step to 39 if the odd level jack is used or to 21 if the even level jack is used.

(*e*) Release the R switch and operate the C switch of the hand test telephone. The linefinder XY switch should restore.

(*f*) Repeat (*c*) through (*e*) above until dial tone is not returned or until all linefinders in the group have been checked for dial tone.

(*g*) Remove the plug of the hand test telephone from the test jack of the linefinder shelf.

(*h*) If dial tone is returned by all linefinders of the group, the linefinders and first selectors will be operating properly.

(*i*) If dial tone is not returned by one linefinder proceed as described in (2) below.

(2) *Testing of switching circuits and associated wiring.*

(*a*) Operate the BSY (busy) switch of the linefinder that failed to return dial tone.

(*b*) Operate the C switch of the hand test telephone and insert the test plug into the MON (monitor) jack of the busied out linefinder.

(*c*) Operate the R switch and release the C switch of the hand test telephone.

(*d*) Listen for dial tone.

1. If dial tone is returned, the linefinder is faulty.

2. If dial tone is not returned, either the first selector or the wiring between the linefinder and the first selector is faulty.

(*e*) Release the R switch, operate the C switch of the hand test telephone and remove the test plug from the MON jack.

(*f*) Operate the C switch of the hand test telephone and insert the test plug into the monitor A jack of the first selector associated with the suspected linefinder.

(*g*) Operate the R switch and release the C switch of the hand test telephone.

(*h*) Listen for dial tone.

1. If dial tone is returned, the wiring between the linefinder and associated selector is faulty.

2. If dial tone is not returned, the first selector is faulty.

(*i*) Release the R switch, operate the C switch, and remove the hand test telephone from the monitor A jack.

c. Testing From Selector to Succeeding Equipment. To isolate a trouble which can involve two selectors (first and second selectors, second and third selectors, or first and third selectors), follow the procedure described below.

(1) *Locating selectors used by calling party.*

(*a*) Locate the group of linefinders which serves the calling party.

(*b*) Use the call tracing procedure for tracing forward (station-to-station) to determine the switching equipment used by the calling party (par. 14).

(*c*) Make a record of the switching circuits used and which switching circuit failed to operate properly.

(2) *Testing of switching circuits and associated wiring.*

(*a*) *Faulty transmission.* If the trouble reported by the calling party is faulty transmission, proceed as described below.

1. Operate the C switch of the hand test telephone and insert the test plug successively into each monitor A jack of the switch train, starting with the first selector.

2. Test the transmission at each jack by talking to the calling party until the trouble is isolated to a specific switching circuit.

3. Remove the test plug of the hand test telephone from the monitor A jack.

4. Check the associated wiring preceding the suspected selector as described in (*b*) below.

(*b*) *XY switch fails to step.*

1. Determine from the GTA drawing which trunk interconnects the suspected selector and the previous selector (par. 10).

2. Locate the grading terminals (tip and ring) on the specific grading terminal board.

3. Connect the alligator clip of the test receiver to ground.

4. Momentarily touch the test probe of the test receiver successively to the tip and ring terminals.

(a) If a click is heard at both terminals or not heard on the ring the suspected selector is faulty.

(b) A click heard on the ring and not on the tip indicates that the previous selector may be faulty.

5. Reconnect the alligator clip to battery.

6. Momentarily touch the test probe to the tip and ring terminals.

(a) If a click is heard at both terminals or not heard on the tip, the suspected selector is faulty.

(b) If a click is heard on the tip and not on the ring, the preceding selector is faulty.

7. Disconnect the alligator clip of the test receiver from ground.

8. Operate the BSY switch of the faulty selector.

(*c*) *Faulty stepping of XY switch.*

1. Request the calling party to disconnect.

2. Operate the BSY switch associated with the suspected switching circuit.

3. Operate the C switch of the hand test telephone and insert the test plug into the monitor A jack.

4. Operate the R switch and release the C switch of the hand test telephone.

5. Dial the appropriate digit of the called party's number. The XY switch should step to the required level and hunt for an idle trunk.

(a) If the XY switch functions properly, the calling party's telephone dial should be checked.

(b) Lf the XY switch failed to func-

tion properly, the selector is faulty.

6. Operate the C switch of the hand test telephone and remove the test plug from the monitor A jack.

7. Operate the BSY switch if the selector is faulty.

d. Connector to Station Line. To isolate a trouble between a connector and a station line, (for example, called telephone answers but cannot be heard), follow the procedure given below.

(1) *Locating connector used for called party.*

(*a*) Locate the connector group which serves the called party's number (par. 14).

(*b*) Find the connector which has stepped to the level and position which correspond to the last two digits of called party's number.

(2) *Testing of associated circuits.*

(*a*) Dial the called party's number from the test desk by using the test selector trunk as described in TM 11–2119.

(*b*) Test the transmission between the called party's telephone and the test desk telephone.

1. If transmission is satisfactory, the suspected connector is faulty.

2. If transmission is not satisfactory, the associated wiring is faulty.

(*c*) Operate the BSY switch of the connector, if faulty.

CHAPTER 3
MAINTENANCE

Section I. PREVENTIVE MAINTENANCE

24. General

Preventive maintenance is work performed on equipment to keep it in good working order. This work is performed periodically and consists of a systematic series of inspection procedures and operational routine tests. Preventive maintenance differs from troubleshooting and repair in that the express purpose is to prevent the occurrence of trouble. This work should be performed during periods of lightest traffic.

25. Preventive Maintenance Procedures

Most of the electrical and mechanical parts used in XY central offices require routine preventive maintenance. However, the kind and amount of such maintenance differs depending on the age of the equipment and the conditions under which a particular installation must operate.

a. Inspection. Make periodic inspections to detect minor defects and signs of worn, damaged, or corroded parts which may later cause trouble. Inspect for the following conditions:

(1) *Overheating.* Look for discoloration, blistering, or bulging of the parts or surface of a cover, leakage of insulating compounds, and oxidation of metal contact surfaces.

(2) *Placement.* Check to see that all leads and cabling are in their proper positions, that insulation is not damaged, and that soldered connections are in good condition.

(3) *Cleanliness.* Check equipment units for accumulation of dust, especially between connecting terminals. Parts, connectors, and connections should be free from dust, corrosion, and other foreign matter. Clean affected parts carefully so as not to damage equipment or change its adjustment.

(4) *Tightness.* Check any connections or mountings which appear to be loose.

b. Lubrication. Check mechanical switches, motor, bearings and other moving parts for proper lubrication. Refer to paragraphs 196 through 203 for lubricating procedures.

c. Cleaning and Conditioning Switchroom. Keep switchrooms clean and dry. Take precautions to exclude dust, dirt, moisture, and insects. Reduce or prevent unnecessary travel of personnel through the switchroom to minimize introduction of dirt or dirt-laden air. For detailed procedures refer to paragraph 195.

d. Cleaning of Equipment. Clean the equipment during periods of light traffic. For cleaning procedures, refer to paragraphs 194 and 195.

e. Ventilation. If forced draft ventilation is provided for operating personnel, filter all air before it enters the switchroom. Seal all windows, unnecessary doors, or other openings. Clean air filters frequently.

f. Humidity. To prevent moisture damage, keep the relative humidity below 60 percent.

Section II. ROUTINE TESTING, GENERAL

26. Procedure

The XY dial central office equipment must be tested periodically to detect equipment faults before serious service interruptions result from the accumulation of such faults. The routine tests, described in this section and paragraphs 31 through 59, determine whether individual units of the equipment are functioning proper-

ly or are in need of repair or adjustment. A high level of equipment efficiency and stability can be achieved through conscientious application of the test routines at properly scheduled intervals.

27. Routine Testing Schedules

The frequency of test routines is determined by the wire chief or the communications officer and depends on such factors as the amount of traffic handled during peak load periods, the size of the central office, the personnel available, and other operating conditions. Routine testing should be performed during periods of light traffic, generally during the early morning hours. Follow the schedule below to insure reliable operation of the central office:

a. Daily Tests.

Routine test	Purpose	Par. ref.
	Switching circuits	
Chain circuit	Check the operation of linefinders and allotters	32
	Supervisory circuits	
Fuse alarm, equipment alarm, and busy tone switch.	Check the alarm buzzer, fuse and equipment alarm lamps, and busy tone switch.	41
Tone generator, ringing machine, and machine interrupter.	Check the operation and transfer of tone generator, ringing machine, and machine interrupter.	42
	Attendant's switchboard	
Night alarm	Check to see that the night alarm buzzer sounds when a line pilot or supervisory pilot lamp lights on incoming calls or disconnect signals.	56

b. Weekly Tests.

Routine test	Purpose	Par. ref.
	Switching circuits	
Line relay	Check operation of line circuits	31
Continuity test:	Check the condition of:	
Selectors	T, R, S, and HS	33
Individual, and individual or trunk hunting connectors.	T, R, S, HS, and SN	36*a*
Trunk circuit plate (2,000 ohms or less).	T, R, and S	37*a*
Trunk circuit plate (3,000 ohms or less).	T, R, and S	38*a*
Combination trunk circuit plate	T, R, and S	39*a*
Selector speed	Check the trunk hunting action of the selectors	33*c*
Operational test:	Check the operation of switching circuits for:	
Linefinder-allotter circuit plates	Seizure and switch-through	32*b*
Selectors	Seizure and switch-through	33*c*
XY PX connectors	Seizure to release	34
XY PBX connectors	Seizure to release	35
Individual, and individual or trunk hunting connectors.	Seizure, switch-through, ringing, trip, answer, and release.	36*a*
Trunk (2,000 ohms or less) circuit plate.	Seizure to release	37*a*
Trunk (3,000 ohms or less) circuit plate.	Seizure to release	38*a*
Combination trunk circuit plate	Seizure to release in both directions	39*a*
	Test desk	
MDF test shoe trunk circuit	Check operation of test shoe and trunk	45*a*
Two-way to line trunk	Check operation of two-way to line trunk	45*b*

Routine test	Purpose	Par. ref.
	Information desk	
Fuse alarm	Check the fuse alarm lamp	50
	Attendant's switchboard	
Cord	Check continuity of cords	54*a*
Headset	Check transmission of headset	55*a*
Position switching	Check the operation of the position switching circuits	55*b*
Peg count meter	Check the operation of PC switches and peg count meters	55*e*
Conference jack	Check the operation of conference circuit	55*f*
Fuse alarm	Check the operation of fuse alarm and MASTER FUSE ALM circuits.	56*b*
Fire alarm	Check the operation of the fire alarm trunks and controls	56*c*
	Power equipment	
Emergency power source	Check the operation of emergency power for the central office	59

c. Monthly Tests.

Routine test	Purpose	Par. ref.
	Switching circuits	
Percent make test	Check the percent make off:	
Selectors	Relay CB	33*d*
Individual, and individual or trunk hunting connectors.	Relay CB	36*c*
Trunk circuit plate (2,000 ohms or less).	Relay CB	37*c*
Trunk circuit plate (3,000 ohms or less).	Relay CB	38*c*
Combination trunk circuit plate	Relay CB	39*c*
	Test desk	
Testing circuits tests	Check performance of:	
	Resistance measuring circuits	44*a*
	Capacitance measuring circuits	44*b*
	Battery testing circuits	44*c*
	Transmission test circuits	44*d*
	High-voltage breakdown test circuits	44*e*
	Pulse speed circuits	44*f*
	Percent make circuits	44*g*
	Howler circuits	44*h*
	Wheatstone bridge circuit	44*i*
	Sounder circuit	44*j*
	Information desk	
Connector intercept, information, and dead selector level intercept trunks.	Check the operation of the circuit plates	46
Dial	Check dial performance	47
Operator's headset	Check transmission of operator's headset	49
	Attendant's switchboard	
Connector intercept, information, and dead selector level intercept trunks.	Check the operation of the circuit plates	51
Cord circuit	Check the operation of the cord circuits	54*b*
Common battery lines	Check operation of common battery line circuits	52
Magneto (local battery) lines	Check operation of magneto line circuits	53
Dial	Check dial performance	54*c*
One-way interposition trunk	Check transmission between positions of attendant's switchboard.	55*c*
Two-way interposition trunk	Check transmission between positions of attendant's switchboard.	55*d*

Routine test	Purpose	Par. ref.
	Miscellaneous	
Hand test telephone	Check performance of hand test telephone	58*a*
Pulsing limits test set	Check performance of pulsing limits test set	58*b*
Pulse speed and percent make test set	Check performance of pulse speed and percent make test set	58*c*
XY switch test set	Check performance of XY switch test set	58*d*
Connector routine test circuit plate	Check performance of connector routine test circuit plate	58*e*
Circuit plate maintenance test set test	Check performance of circuit plate maintenance test set	58*f*

d. Semiannual Tests. Perform the following:

Routine test	Purpose	Par. ref.
	Switching circuits	
Line or trunk	Check outside lines and trunks	40
	Miscellaneous	
Distributing frames and grading panels	Check connections and heat coils	57

28. Additional Maintenance Data

a. The following diagrams, contained in TM 11–2116, may be used for circuit analysis during routine testing of the switching circuits.

Schematic diagram	Fig. No.
Line circuit	35
Linefinder-allotter circuit	51
Nondigit-canceling selector	84
Digit-canceling selector	90
XY–PX connector	63
XY–PBX connector	73
Individual line connector	100
Individual or trunk hunting connector	109
Trunk circuit, two-way dial-to-dial loop, battery and ground pulsing (for loops of 2,000 ohms or less).	117
Trunk circuit, two-way dial-to-dial loop, battery and ground pulsing (for loops of 3,000 ohms or less).	125
Combination trunk circuit	131
Information trunk circuit	133
Inspector's ringback circuit	135
Connector intercept circuit	138
Linefinder shelf, common equipment and supervisory circuit.	140
Connector shelf, common equipment and supervisory circuit.	144
Selector shelf, common equipment and supervisory circuit.	148
Trunk shelf, common equipment and supervisory circuit.	151

b. The following diagrams, contained in TM 11–2119, may be used for circuit analysis during routine testing of the test desk.

Schematic diagram	Fig. No.
Two-way to line trunk circuit	10
Selector level trunk circuit	11
MDF trunk circuit	12
Test selector trunk circuit	13
Main testing circuit	33
Wheatstone bridge testing circuit	34
Transmission testing circuit	35
Current on test leads circuit	36
High-voltage breakdown test circuit	37
Pulse speed and percent make test circuit	38
Howler circuit	40
Sounder circuit	41
Test selector circuit	74
Test connector circuit	75

c. The following circuits, contained in TM 11–2117, may be used for circuit analysis during routine testing of the attendant's switchboard and the information desk.

Schematic diagram	Fig. No.
Convertible line circuit	17
Jack circuits	18
Cord, position and dial, and operator's circuit	98
Cord test circuit	42
Peg count circuit	43
Line and supervisory pilot circuits	46
Night alarm circuit	47
Fire alarm trunk circuit	62
Information desk circuits	97

29. Test Equipment and Materials Required

a. Test Equipment. The following chart lists the test equipment for routining the circuit plates and equipment. The associated technical manual and the assigned common name (if any) are also listed:

Quantity	Test equipment	Technical manual	Common name
1	Hand test telephone	TM 11-2120	
1	Hand test telephone with alligator clips attached to the T and R leads.		
1	Common battery telephone with alligator clips attached to the T and R leads.		CB telephone.
1	Field-type telephone, connected as a local battery telephone, with alligator clips attached to the T and R leads.		LB telephone.
1	Circuit plate maintenance test set	TM 11-2120	
1	Signal Generator SG-15/PCM	TM 11-2096	Signal generator.
1	Decibel Meter ME-22/PCM	TM 11-2096	Db meter.
1	Test Set I-142, I-142A, I-142-B or Telephone Test Set AN/PTM-6.	TM 11-2062	
1	Pulse speed and percent make test set	TM 11-2120	
1	Test Set TS-190/U	TM 11-468	
1	Multimeter TS-352/U or equal	TM 11-5527	Multimeter.
1	24-volt buzzer with self-contained 22½-volt battery		Buzzer.

b. Materials. The following materials are required to perform the routine tests.

1 Jack strip
1 300-ohm resistor (½-watt)
1 1,200-ohm resistor (½-watt)
1 45-volt test battery

30. Monitoring Procedure

Before busying out a circuit plate that is to be routine tested, determine that it is not in use. A monitor (MON) lamp is provided on selector, individual connector, and individual or trunk hunting connector circuit plates. The MON lamp is dimly or brightly lighted when the circuit plate is in use. Operate the busy (BSY) switch only when the MON lamp is *not* lighted. If a circuit plate is not equipped with a MON lamp, follow the monitoring procedure described below to determine whether or not the circuit plate is in use.

a. Operate the C switch of the hand test telephone and insert the plug into the monitor A jack.

b. Determine whether the circuit plate is busy by holding the C switch operated and listening to the receiver.

c. If the circuit is busy, hold the C switch operated and remove the plug from the jack.

d. Tag the busy circuit plate to indicate that it was not tested. (Test the circuit plate when it is not busy and remove the tag).

e. If the circuit is idle, operate the BSY switch and proceed with the routine test.

Section III. SWITCHING CIRCUITS, ROUTINE TESTING

31. Line Relay Tests (Weekly)

Schedule different groups of line relays for testing each week. Test a sufficient number of line relays each week so that the testing of all line relays can be accomplished over approximately 6-month intervals.

a. Connect the hand test telephone with the alligator clips across the T and R lugs of the line circuit at the MDF. Hold the C switch operated.

b. Monitor the line.

(1) If the line is busy, hold the C switch operated and disconnect the alligator clips of the hand test telephone.

(2) Mark the line busy and test the line when it is idle.

(3) If the line is idle, proceed with the test below.

c. Release the C button of the hand test telephone. Dial tone should be heard.

d. Dial the digit of a vacant level (any unused level as shown in the trunking diagram (fig. 5)) on the hand test telephone. Busy tone should be heard.

e. Operate the C switch and disconnect the alligator clips of the hand test telephone.

32. Linefinder-Allotter Tests

a. Chain Circuit Test (Daily).

(1) Operate the busy and reset (B & R) switch of the allotter A circuit plate. The transfer (TRNS) lamp of allotter A should light and the functions of allotter A should be taken over by allotter B.

(2) Restore any operated linefinder busy (BSY) switches associated with allotter A.

(3) Operate the test (TST) switch of the allotter A circuit plate and observe the stepping of the linefinders. Each linefinder should take 10 steps in the X direction, 11 steps in the Y direction, and then release. As each linefinder releases, the next successive linefinder should operate. While each linefinder is stepping, watch for slow, uneven, or other abnormal operation.

(4) Operate the BSY switch of any linefinder which fails to operate or operates abnormally.

(5) Restore the TST switch of allotter A after all linefinders have been tested.

(6) Restore the B & R switch.

(7) Repeat (1) through (6) above for allotter B; observe the operation of the linefinders.

b. Operational Test (Weekly).

(1) Insert the plug of the hand test telephone into the odd level jack (connected to line circuit 39) of the linefinder shelf, supervisory circuit plate. Observe which linefinder is selected.

(2) Listen for dial tone and then dial the digit of a vacant level (any unused level as shown in the trunking diagram (fig. 5)). The dial tone should change to a busy tone, or the intercept operator will answer.

(3) Operate the C switch on the hand test telephone. The linefinder should release promptly.

(4) Release the C switch on the hand test telephone. The next idle linefinder should be selected.

(5) Repeat (2) through (4) above until all linefinders have been selected by allotter A.

(6) Operate the B & R switch of allotter A. The TRNS lamp of allotter A should light and the functions of allotter A should be taken over by allotter B.

(7) Repeat (2) through (4) above until all linefinders have been selected by allotter B.

(8) Restore the B & R switch of allotter A.

(9) Remove the plug of the hand test telephone from the odd level jack.

(10) Insert the plug of the hand test telephone into the even level jack (connected to line circuit 21) of the linefinder shelf of the supervisory circuit plate. Observe which linefinder is selected.

(11) Repeat (2) through (4) above until all linefinders have been selected by allotter B.

(12) Operate the B & R switch of allotter B. The TRNS lamp of allotter B should light and the functions of allotter B should be taken over by allotter A.

(13) Repeat (2) through (4) above until all linefinders have been selected by allotter A.

(14) Restore the B & R switch of allotter B.

(15) Remove the hand test telephone from the even level jack.

33. Selector Tests

a. Operational Test (Weekly).

(1) *General.* Test the selectors operationally in groups of 10, use a different set of 10 each time the test is made so that ultimately all selectors will have been tested. The operational test checks each level of a selector for

proper operation. The stepping of the selector in the Y direction, after a specific level is dialed, is controlled by the wiring of the XX bank (and the S bank if the selector level is an unused level). The bank wiring for each selector level is shown in the trunking diagram (fig. 5). Each level of the XX bank for the digit-canceling selector has one of four wiring options. The options are the Q, F, V, and Z wiring. The F wiring is used as an option for the nondigit canceling selector. The latter should hunt for an idle trunk (as in the Q wiring below) if the F wiring is *not* encountered.

(*a*) *Q wiring.*

1. The selector should automatically hunt in the Y direction for an idle trunk to the succeeding switching equipment.

2. The monitor A lamp should light dimly when an idle trunk is seized.

3. Busy tone should be heard in the hand test telephone if all trunks are busy.

(*b*) *F wiring.*

1. The selector should take 11 steps in the Y direction.

2. Busy tone should be returned to the calling station with restricted service.

(*c*) *V wiring.*

1. The selector should release at the completion of the X direction stepping.

2. When the next digit is dialed, the selector should step to the dialed level and operate in accordance with the type of wiring encountered at the new level.

(*d*) *Z wiring.*

1. The selector should take 11 steps in the Y direction.

2. Busy tone should be returned to the calling station.

(2) *Testing.*

(*a*) Operate the busy (BSY) switch of the selector circuit plate to be tested only when the monitor (MON) lamp is not lit.

(*b*) If the selector contains a restricted level (F wiring), apply ground to the HS lead by grounding the sleeve of the test B (B) jack.

(*c*) Operate the R switch of the hand test telephone and then insert the plug of the hand test telephone into the monitor A (A) jack. The MON lamp should light brightly.

(*d*) Dial digit 1 on the hand test telephone. The selector should take one step in the X direction and then operate as described in (1) above, depending on the wiring option encountered at the first level.

(*e*) Operate the C switch of the hand test telephone. The selector should restore.

(*f*) Dial digit 1 again if busy tone is returned when dialing a level with the Q wiring.

(*g*) Dial the next digit on the hand test telephone to test the next level. The selector should operate as described in (1) above, depending on the wiring option encountered at the dialed level.

(*h*) Repeat (*e*) and (*g*) above until all levels of the selector have been tested.

(*i*) Operate the C switch of the hand test telephone and then remove the plug of the hand test telephone from the monitor A jack. The MON lamp should go out.

(*j*) Remove ground from the sleeve of the test B jack if applied ((*b*) above).

(*k*) Restore the BSY switch if the selector functioned properly at all levels.

b. Continuity Test (Weekly). Check the condition of the tip (T), ring (R), sleeve (S), and helping sleeve (HS) leads of the selector by following the selector continuity test procedure, using the circuit plate maintenance test set in TM 11–2120.

c. Selector Speed Test (Weekly). Check the trunk hunting action of the selector and the

stepping speed of the selector XY switch in the Y direction by following the selector speed test procedure, using the circuit plate maintenance test set in TM 11–2120. Test 100 selectors weekly, using a different group of 100 selectors each time the test is performed, so that ultimately (approximately 14 weeks for a 5,000-line exchange) all selectors will have been routined. When all selectors have been tested, repeat the test schedule, starting with the first 100 selectors, so that each selector is retested at regular intervals.

d. Percent Make Test (Monthly). Check the operation of relay CB in the selector under simulated conditions of low resistance, high resistance, and low leak resistance line loops by following the selector percent make test procedure, using the circuit plate maintenance test set in TM 11–2120.

Note. The pulsing limits test set and pulse speed and percent make test set also may be used to perform the percent make test (refer to TM 11–2120).

34. XY PX Connector, Operational Test (Weekly)

a. After the circuit plate is busied out (par. 30), operate the R switch of the hand test telephone and release the C switch. Dial tone should be received.

b. After receiving dial tone, dial the assigned number of the test telephone. Ringback tone should be received in the hand test telephone.

c. Release the R switch and talk with the person answering the call to determine whether ringing and transmission are satisfactory.

d. Advise the called party to hang up and then operate the C switch of the hand test telephone. The connector should restore only after both parties disconnect.

e. Release the C switch and dial an unused number, a test number, or the number of any telephone with the hand set lifted from the cradle. Busy tone should be returned.

f. Operate the C switch of the hand test telephone. The connector should restore.

g. Remove the plug of the hand test telephone from the monitor A jack.

h. If the circuit plate operated properly, restore the BSY switch.

i. If trouble is indicated, record the trouble. Do not restore the BSY switch.

j. Test the remaining circuit plates, first monitoring each circuit plate (par. 30).

35. XY PBX Connector, Operational Test (Weekly)

a. Station-to-Station Test. Follow the procedure in paragraph 34*a* through *f*.

b. Station-to-Parent-Exchange Test.

(1) Release the C switch of the hand test telephone. Dial tone should be received.

(2) After receiving dial tone, dial the digit 9 on the hand test telephone. Dial tone should be supplied by the parent exchange.

Note. Operate the C switch if busy tone is received. Repeat (1) and (2) above until dial tone is received.

(3) Dial the number of the wire chief's test desk. Ringback tone should be received.

(4) When the called party answers, identify yourself and explain that, as prescheduled, you are testing the transmission path between both telephones.

(5) When the transmission test is completed, operate the C switch on the hand test telephone. The connector should release.

(6) Release the C switch and dial the digit 0 on the hand test telephone to reach the attendant's switchboard. Ringback tone should be received.

(7) Repeat (4) and (5) above.

c. Restricted Service Test.

(1) Apply ground to the HS lead to simulate a restricted service line.

(2) Release the C switch of the hand test telephone. Dial tone should be received.

(3) After receiving dial tone, dial the digit 9 on the hand test telephone. Busy tone should be received.

(4) Operate the C switch. The connector should release.

(5) Disconnect the ground to the HS lead.

d. Conference Service Test.

(1) Have an assistant dial the conference service number from a telephone located in the switchroom.

(2) After the call is placed, release the C switch and dial the conference service number from the hand test telephone.
(3) Test the transmission path with the assistant.
(4) When the transmission test is completed, operate the C switch on the hand test telephone. The connector should restore.

e. Executive Right-of-Way Service Test.
(1) Connect negative battery through a 300-ohm resistor to the HS lead.
(2) Request an assistant to lift the hand set of the switchroom telephone.
(3) Release the C switch of the hand test telephone and dial the number of the assistant's telephone. Busy tone should be received.
(4) Dial any additional digit on the hand test telephone.
(5) With the assistant test the transmission path between both telephones.
(6) Request the assistant to hang up. The called telephone should ring and ringback tone should be received in the hand test telephone.
(7) Operate the C switch of the hand test telephone. The connector should restore.

36. Individual and Individual or Trunk Hunting Connector Tests

a. Operational Test (Weekly).
(1) Insert the test plug of the hand test telephone into the monitor A jack.
(2) Dial the digits 99. (When testing trunk hunting connectors, see that the XY switch steps automatically to 90).
(3) Listen to the receiver of the hand test telephone. The following tones should be heard:
(*a*) Two periods of ringback tone.
(*b*) Three periods of dial tone.
(*c*) Reverse battery clicks at the rate of 120 times per minute.

Note. The connector routine test circuit plate also may be used to perform the operational test under simulated line conditions (refer to TM 11–2120).

b. Continuity Test (Weekly). Check the condition of the T, R, S, and HS leads of the connector circuit plate by following the continuity test procedure on connectors, using the circuit plate maintenance test set in TM 11–2120.

c. Percent Make Test (Monthly). Check the operation of relay CB in the connector circuit plate under simulated conditions by following the percent make test procedure on connectors, using the circuit plate maintenance test set in TM 11–2120.

Note. The pulsing limits test set and pulse speed and percent make test set also may be used to perform the percent make test. (Refer to TM 11–2120.)

d. Operational Test (Monthly). Check the complete operation of the connector circuit plate from seizure to release by following the operational test procedure on connectors, using the circuit plate maintenance test set in TM 11–2120.

37. Trunk Circuit Plate (2,000 Ohms or Less) Tests

a. Operational Test (Weekly).
(1) After the circuit plate has been busied out (par. 30), operate the R switch and release the C switch of the hand test telephone.
(2) Dial the appropriate number on the hand test telephone for a connection to the wire chief's test desk at the distant office. This should cause the supervisory lamp on the wire chief's test desk to light.

Note. When calling a distant PBX, dial the predetermined test number for a connection to the test telephone at the PBX.

(3) When the wire chief answers, identify yourself and inform him that, as prescheduled, you are prepared to perform the continuity and percent make tests (*b* and *c* below). The circuit plate under test is functioning properly if a conversation can be carried on between the wire chief at the test desk and the hand test telephone.
(4) Operate the C switch of the hand test telephone to release the circuit plate tested and remove the plug from the monitor A jack.
(5) If the circuit plate operated properly, restore the BSY switch.
(6) If trouble is indicated, record the trouble. Do not restore the BSY switch.

b. Continuity Test (Weekly). Check the condition of the T, R, S, and HS leads of the trunk circuit plate (2,000 ohms or less) by following the continuity test procedures on trunk circuit plates, using the circuit plate maintenance test set in TM 11–2120.

c. Percent Make Test (Monthly). Check the operation of relay CB in the trunk circuit plate (2,000 ohms or less) under simulated conditions by following the percent make test procedures on trunks, using the circuit plate maintenance test set in TM 11–2120.

38. Trunk Circuit Plate (3,000 Ohms or Less) Tests

a. Operational Test (Weekly).

(1) *Outgoing calls.* Follow the procedure described in paragraph 37*a*.

(2) *Incoming calls.*

(*a*) Operate the C switch and insert the plug of the hand test telephone into the monitor B jack of the circuit plate to be tested.

(*b*) If the circuit plate is idle, release the C switch and operate the R switch of the hand test telephone.

(*c*) Dial the appropriate number for a connection to the wire chief's test desk within the exchange. This should cause the supervisory lamp on the test desk to light.

(*d*) Follow the procedure described in paragraph 37*a*.

(*e*) Test the remainder of the circuit plates. In each case, the trunk circuit plate under test is functioning properly if a conversation can be carried on between the assistant at the hand test telephone and the wire chief at the test desk.

b. Continuity Test (Weekly). Check the condition of the T, R, S, and HS leads of the trunk circuit plate (3,000 ohms or less) by following the continuity test procedures, using the circuit plate maintenance test set in TM 11–2120.

c. Percent Make Test (Monthly). Check the operation of the CB relay in the trunk circuit plate (3,000 ohms or less) under simulated conditions by following the percent make test procedures, using the circuit plate maintenance test set in TM 11–2120.

Note. The pulsing limits test set and pulse speed and percent make test set also may be used to perform the percent make test (TM 11–2120).

39. Combination Trunk Circuit Plate Tests

a. Operational Test (Weekly).

(1) Insert the answer cord plug into an idle trunk jack associated with the distant office to be called. The associated busy lamp at the attendant's switchboard should light.

(2) Operate the associated TALK-MON switch to the TALK position. Dial tone should be heard.

(3) Dial the appropriate number for a connection to the operator at the attendant's switchboard at the distant office.

(4) When the operator answers, inform him of the prearranged tests, then proceed to (5) below.

(5) Remove the answer cord plug from the trunk jack.

(6) Return the TALK-MON switch to its normal position.

(7) Wait for a return call from the distant office. When the operator rings, the incoming line and busy lamps should light.

(8) Insert the answer cord into the trunk jack associated with the incoming line lamp. The incoming lamp should go out.

(9) Operate the associated TALK-MON switch to the TALK position. If a conversation can be carried on, the trunk circuit plate is functioning properly.

(10) Restore the TALK-MON switch.

(11) Remove the call cord plug from the trunk jack. The busy lamp should go out after both operators disconnect.

b. Continuity Test (Weekly). Check the condition of the T, R, S, and HS leads of the combination trunk circuit plate by following the continuity test procedures, using the circuit plate maintenance test set, in TM 11–2120.

c. Percent Make Test (Monthly). Check the operation of the CB relay in the combination trunk circuit plate under simulated conditions by following the percent make test procedures, using the circuit plate maintenance test set in TM 11–2120.

Note. The pulsing limits test set and pulse speed and percent make test set also may be used to perform the percent make test. (Refer to TM 11–2120.)

40. Line or Trunk Tests (Semiannual)

a. The facilities of the test desk are used for routine testing of the lines or trunks. Connection to the desired test connector is established over a test selector trunk. After connection is made to a line to be tested, the group of tests listed below should be performed to determine the condition of the line.

(1) Foreign battery (loop) test.
(2) Foreign battery (tip) test.
(3) Foreign battery (ring) test.
(4) Shorts test.
(5) Tip ground test.
(6) Ring ground test.
(7) Loop capacitance test.
(8) Tip capacitance test.
(9) Ring capacitance test.

b. Follow the multiline testing procedure in TM 11–2119. Schedule weekly line or trunk tests. Test different 100-line groups each time, so that each line or trunk is regularly tested at approximately 6-month intervals.

Section IV. SUPERVISORY AND COMMON EQUIPMENT, ROUTINE TESTING

41. Fuse Alarm, Equipment Alarm, and Busy Tone (BT) Switch Tests (Daily)

a. Linefinder Shelf.

(1) Move and hold an idle linefinder XY switch off normal. The RLS lamp should light.
(2) Release the XY switch. The RLS lamp should go out.
(3) Momentarily insert a screwdriver blade between the fuse and the alarm bar of each fuse listed below. The associated lamp should light.

Fuse	Lamp
Line circuit	EFA
Linefinder	FA
Meter	FA
Allotter A	ALLR A
Allotter B	ALLR B

b. Selector Shelf.

(1) Move and hold an idle XY switch off normal. The RLS lamp should light.
(2) Release the XY switch. The RLS lamp should go out.
(3) Insert a screwdriver blade between any fuse and the alarm bar. The (FA) lamp should light.
(4) Remove the screwdriver. The FA lamp should go out.
(5) Monitor, busy out, and seize a selector circuit plate (par. 30). Dial tone should be heard.
(6) Operate the BT switch. Dial tone should not be heard.
(7) Restore the BT switch. Dial tone should be heard.
(8) Remove the plug of the hand test telephone from the monitor A jack.

c. Connector Shelf. Follow the procedures in *b* (1) through (4) above.

d. Trunk Shelf. Follow the procedures in *b* (3) and (4) above.

e. Row, Group, and Common Supervisory Equipment. In addition to the fuse alarm (EFA, FA, ALLR A, and ALLR B) lamps and the equipment alarm (RLS) lamps (*a–d* above), the alarms indicated in (1) through (7) below should operate on the row, group, and common supervisory equipment.

(1) The LEFT SIDE lamp should light in the row supervisory circuit when a fuse or equipment alarm lamp lights on the left side of the row.
(2) The RIGHT SIDE lamp should light on the row supervisory circuit when a fuse or equipment alarm lamp lights on the right side of the row.
(3) A FUSE lamp should light on the group supervisory equipment when a fuse alarm lamp on the shelf equipment lights. There are four FUSE lamps, one for each group supervisory circuit.
(4) An EQPT lamp should light on the group supervisory equipment when an equipment alarm lamp on the shelf equipment lights. There are four EQPT lamps, one for each group supervisory circuit.
(5) The FUSE lamp on the common supervisory equipment should light when a

fuse alarm lamp on the shelf equipment lights.

(6) The EQPT lamp on the common supervisory equipment should light when an equipment alarm lamp lights.

(7) The buzzer on the power board should sound each time a fuse or equipment alarm lamp on the shelf equipment lights.

42. Tone Generator, Ringing Machine, and Machine Interrupter Test (Daily)

a. Insert the plug of the hand test telephone into the monitor A jack of a connector circuit plate.

b. Dial the digits 99.

c. Listen to the receiver of the hand test telephone. The following tones should be heard in the order listed:

(1) Two periods of ringback tone.

(2) Three periods of dial tone.

(3) Continuous reverse battery clicks.

d. Operate the C pushbutton on the hand test telephone and remove the plug of the hand test telephone from the monitor A jack.

e. Operate the TRANS KEY switch on the tone generator panel.

f. Restore the RM 1 ST switch on the ringing control panel.

g. Operate the INT TRANS switch on the ac interrupter and machine panel.

h. Repeat *a* through *d* above.

i. Restore the TRANS KEY switch on the tone generator panel.

j. Operate the RM 1 ST switch on the ringing control panel.

k. Restore the INT TRANS switch on the ac interrupter and machine panel.

43. Inspector's Ringback Circuit Test (Weekly)

a. Operate the C switch of the hand test telephone and insert the plug of the hand test telephone into a monitor jack of the inspector's ringback circuit plate.

b. When the circuit is idle, operate the BSY switch associated with the monitor jack being used.

c. Momentarily release the C switch.

d. When the C switch is reoperated, ringing current should be heard in the receiver of the hand test telephone.

e. Momentarily release the C switch.

f. When the C switch is reoperated, ringback tone should *not* be received.

g. Remove the plug of the hand test telephone from the monitor jack and restore the BSY switch.

Section V. TEST DESK, ROUTINE TESTING

44. Test Desk Tests (Monthly)

a. Resistance Measuring Circuits.

(1) Perform a meter zero adjustment (TM 11–2119).

(2) Operate the TEST SEL TRK switch to the AUX position.

(3) Operate the TEST AUX-CO AUX switch to the TEST AUX position. When the test selector is seized, the test supervisory lamp should light.

(4) Dial the number of the switchroom telephone.

(5) Remove the handset from the cradle when the telephone rings.

(6) Operate the LOOP LOW-LOOP switch to the LOOP position. The meter needle should indicate the resistance of the loop.

(7) Restore the LOOP LOW-LOOP switch to normal.

(8) Connect ground to the tip lead of the switchroom telephone at the MDF.

(9) Operate the TIP GROUND LOW TIP GROUND switch to the TIP GROUND position. The meter needle should indicate 5,000 ohms or less on the upper scale.

(10) Restore the TIP GROUND LOW-TIP GROUND switch to normal, then operate it to the TIP GROUND LOW position. Record the meter reading.

(11) Divide the result by 100. The value obtained should correspond to the predetermined value of the resistance (in ohms) from the test desk to ground over the tip lead.

(12) Restore the TIP GROUND LOW-TIP GROUND switch to normal.
(13) Disconnect the ground from the tip (T) terminal and connect a ground to the ring (R) terminal of the switchroom telephone at the MDF.
(14) Follow the procedure described in (9) through (12) above, except use the RING GROUND LOW-RING GROUND switch instead of the TIP GROUND LOW-TIP GROUND switch.
(15) Disconnect ground from the R terminal at the MDF.
(16) Restore all switches to normal.
(17) Hang up the switchroom telephone.

b. Capacitance Measuring Circuits.
(1) Follow the procedure in *a*(2) through (5) above.
(2) Operate the DIRECT MAKE-LOOP CAPACITY switch to the LOOP CAPACITY position.
(3) Record the maximum reading observed on the lower scale of the meter. The meter indication should agree with the predetermined capacitance of the line being tested.
(4) Restore the DIRECT MAKE-LOOP CAPACITY switch to normal.
(5) Perform a preliminary capacitance test (TM 11–2119).
(6) Operate the SPEED-TIP CAPACITY switch to the TIP CAPACITY position.
(7) Record the maximum reading observed on the lower scale of the meter. The reading should correspond to that obtained in (5) above for tip to ground capacitance.
(8) Restore the SPEED-TIP CAPACITY switch to normal.
(9) Operate the PERCENT MAKE-RING CAPACITY switch to the RING CAPACITY position.
(10) Record the maximum reading observed on the lower scale of the meter. The reading should correspond to that obtained in (5) above for ring to ground capacitance.
(11) Restore all switches to normal.
(12) Hang up the switchroom telephone.

c. Battery Testing Circuits.
(1) Connect a 45-volt test battery across the PT and PR binding posts, with the negative side of the battery source to the PR binding post.
(2) Observe the meter. The meter needle should indicate 45 volts.
(3) Momentarily operate the MR switch. The meter needle should move off scale (left).
(4) Restore the MR switch. The meter needle should move on scale.
(5) Remove the 45-volt test battery. The meter needle should restore to normal.
(6) Connect the 45-volt test battery source across the PT and PR terminals on terminal board 1 (positive battery (+) to terminal 16 and negative battery (—) to terminal 17).
(7) Observe the meter. The meter needle should indicate 45 volt.
(8) Operate the HVBT RING-RING BATTERY switch to the RING BATTERY position. The meter needle should continue to indicate 45 volts.
(9) Restore the HVBT RING-RING BATTERY switch to normal. The meter needle should continue to indicate 45 volts.
(10) Operate the REVERSE-TOLL GEN switch to the REVERSE position. The meter needle should indicate off scale (left).
(11) Operate the HVBT TIP-TIP BATTERY switch to the TIP BATTERY position. The meter should indicate 45 volts.
(12) Restore the REVERSE-TOLL GEN switch and the HVBT TIP-TIP BATTERY switch to normal. The meter needle should indicate 45 volts.
(13) Remove the test battery.

d. Transmission Test Circuits.
(1) Follow the procedure in *a*(2) through (5) above.
(2) Operate the TRANSMISSION TEST-TEST CURRENT switch to the TRANSMISSION TEST position.
(3) Adjust the TRANS TEST rheostat until the meter needle indicates 40 (40 milliamperes) on the lower scale.

(4) Request an assistant to talk into the transmitter of the switchroom telephone. Determine if the transmission of speech is of the proper quality.
(5) Restore all switches to normal.
(6) Hang up the switchroom telephone.

e. High-Voltage Breakdown Test Circuits.

(1) Follow the procedure in *a*(2) through (5) above.
(2) Operate the HVBT TIP-TIP BATTERY switch to the HVBT TIP position. The HVBT lamp should flash at a rate of 120 times per minute to indicate that high voltage is being applied to the tip conductor. The meter needle should not deflect (assuming that the insulation quality of the line under test is good).
(3) Operate the HVBT RING-RING BATTERY switch to the HVBT RING position. The HVBT lamp should flash at a rate of 120 times per minute to indicate that high voltage is being applied to the ring conductor. The meter needle should not deflect.
(4) Restore all switches to normal.
(5) Hang up the switchroom telephone.

f. Pulse Speed Circuit.

(1) Operate the WB LOOP-SET 100 switch to SET 100 position.
(2) Operate the SPEED-TIP CAPACITY switch to the SPEED position.
(3) Adjust the SET 100 rheostat until the meter needle indicates 100 on the lower scale.
(4) Restore the WB LOOP-SET 100 switch to normal.
(5) Operate the TEST AUX-CO AUX switch to the TEST AUX position.
(6) Operate the DIAL LOOP-RELEASE PERM switch to the DIAL LOOP position.
(7) Adjust the PRESET rheostat until the meter needle indicates 10 times the expected reading on the lower scale.
(8) Dial the digit 0. The meter needle should move, indicating the actual speed of the impulses received. For example, if the dial under test has a pulse speed of 12 pulses per second, the meter needle should move slowly toward 120 and become steady at 120 by the time the last pulse is received.
(9) After the last pulse of the digit is received, the meter needle should indicate the preset value.
(10) Obtain a more accurate dial speed reading by readjusting the PRESET rheostat ((8) above) until the meter needle indicates the value nearest the steady value.
(11) Repeat the procedure described in (8) through (10) above.
(12) Continue to make the speed test until the meter needle remains steady throughout the entire series of pulses.
(13) When this condition exists, record the reading observed on the lower scale of the meter and divide by 10. The result is the pulse speed of the dial in pulses per second. The dial speed should be 10 pulses per second ±2 pulses per second.
(14) Restore all switches to normal when the test is completed.

g. Percent Make Circuit.

(1) Operate the WB LOOP-SET 100 switch to the SET 100 position.
(2) Operate the PERCENT MAKE-RING CAPACITY switch to the PERCENT MAKE position.
(3) Follow the procedure described in *f* (3) through (6) above.
(4) Adjust the PRESET rheostat until the meter needle indicates 40 times the expected reading on the lower scale.
(5) Dial the digit 0. The meter needle should move slowly in the direction of the actual percent make of the pulsing contacts. For example, if the dial under test has a percent make of 50, the meter needle will move slowly toward 50 (lower scale) and become steady at this reading by the time the last pulse is received.
(6) When the last pulse of the digit dialed is received, the meter needle should indicate the preset value.
(7) Obtain a more accurate percent make reading by readjusting the PRESET rheostat ((5) above) until the meter

needle indicates the value nearest to the steady value.

(8) Repeat the procedure described in (5) through (7) above.

(9) Continue to make the percent make test until the meter needle remains steady throughout the entire series of pulses.

(10) When this condition exists, record the reading observed on the lower scale of the meter. This reading is the percent make of the pulsing contacts and should be approximately 38 percent.

(11) Restore all switches to normal when the test is completed.

h. Howler Circuit.

(1) Operate the TEST SEL TRK switch to the AUX position.

(2) Operate the TEST AUX-CO AUX switch to the TEST AUX position. When the test selector is seized, the test selector supervisory lamp should light.

(3) Dial the telephone of the switchroom telephone.

(4) Lift the handset from the cradle of the switchroom when the telephone rings.

(5) Operate the HOWLER AUX-HOWLER PRIM switch to the HOWLER AUX position.

(*a*) The HLR lamp should flash at a rate of 60 times per second.

(*b*) The night alarm buzzer should sound (if the NA switch is operated).

(*c*) The howler tone should be applied to the test line.

(6) Listen for howler tone at the switchroom telephone.

(7) Replace the handset of the switchroom telephone on the cradle. The HLR lamp should stop flashing when the handset is replaced.

(8) Restore all switches to normal.

i. Wheatstone Bridge.

(1) Follow the procedure described in *a* (2) through (5) above.

(2) Operate the WB LOOP-SET 100 switch to the WB LOOP position.

(3) Measure the resistance of the loop by operating the controls of the Wheatstone bridge in accordance with the instructions given in TM 11–2119.

(4) Restore the WB LOOP-SET 100 switch to normal.

(5) Ground the tip (T) terminal of the switchroom telephone at the MDF.

(6) Operate the WB T–G—WB R–G switch to the WB T–G position.

(7) Measure the tip to ground resistance by operating the controls of the Wheatstone bridge in accordance with the instructions given in TM 11–2119.

(8) Restore the WB T–G—WB R–G switch to normal.

(9) Disconnect the ground from the T terminal.

(10) Connect ground to the R terminal at the MDF.

(11) Operate the WB T–G—WB R&G switch to the WB R–G position.

(12) Measure the ring to ground resistance by operating the controls of the Wheatstone bridge in accordance with the instructions given in TM 11–2119.

(13) Disconnect the ground from the T terminal at the MDF.

(14) Restore all switches to normal.

(15) Hang up the switchroom telephone.

j. Sounder.

(1) Operate the SOUNDER AUX-SOUNDER PRIM switch to the SOUNDER AUX position.

(2) Follow the procedure in *a*(2) through (5) above.

(3) Lift the handset of the switchroom telephone from the cradle.

(*a*) The sounder should sound.

(*b*) The SDR lamp on the test desk should light.

(4) Operate the SOUNDER AUX-SOUNDER PRIM switch to the SOUNDER PRIM position.

(*a*) The sounder should continue to sound.

(*b*) The SDR lamp should remain lighted.

(5) Operate the SOUNDER SW switch.

(*a*) The sounder should stop operating.

(*b*) The SDR lamp should go out.

(6) Hang up the switchroom telephone.
(a) The sounder should sound.
(b) The SDR lamp should light.
(7) Restore all switches to normal.

45. Test Desk Trunk Circuits (Weekly)

a. MDF Test Shoe Trunk Test.
(1) Insert a test shoe into the protector blocks of the switchroom telephone at the MDF.
(2) Operate the MDF IN switch to the PRIM position.
(3) Request an assistant to lift the handset from the cradle of the switchroom telephone.
(4) Test the quality of transmission between the test desk telephone and switchroom telephone.
(5) When the test is completed, restore all switches to normal.
(6) Remove the test shoe from the protector block on the MDF.
(7) Repeat (1) through (6) above with the second test shoe.
(8) Restore all switches to normal.

b. Two-Way to Line Trunk Test.
(1) Operate the 2 WAY TRK switch to the PRIM position.
(2) Dial the number of the switchroom telephone.
(3) Follow the procedure described in *a* (3) through (5) above.

Section VI. INFORMATION DESK, ROUTINE TESTING

46. Connector Intercept, Information, and Dead Selector Level Intercept Trunk Tests (Monthly)

a. Insert the plug of the operator's headset into the headset jacks of the information desk.

b. Request an assistant to monitor (par. 30), busy out, and insert the plug of the hand test telephone into the monitor A jack of the trunk circuit plate to be tested. The associated incoming and hold lamp on the information desk should light.

c. Operate the associated *talk-hold* switch at the information desk to the *talk* position. The incoming and hold lamp should go out.

d. Test the transmission path between the two telephones.

e. Operate the *talk-hold* switch to the hold position. The incoming and hold lamp should light.

f. Operate the switch to the talk position. The lamp should go out.

g. Request the assistant to remove the plug of the hand test telephone from the monitor A jack.

h. Restore the *talk-hold* switch.

47. Dial Test (Monthly)

a. Remove the rear panel from the information desk.

b. Prepare the pulse speed and percent make test set in accordance with the instructions contained in TM 11–2120.

c. Connect the PULSE and PULSE GRD terminals of the test set to terminals 41 and 42 of terminal board 2 respectively.

d. Operate the *talk-hold* switch of the first outdial-to-line trunk to the *talk* position.

e. Perform the pulse speed test as described in TM 11–2120.

f. Operate the FL/WO switch on the information desk.

g. Reset the test set and perform the percent make test as described in TM 11–2120.

h. Restore the *talk-hold* switch.

i. Remove the connections between the PULSE and PULSE GRD terminals and terminals 41 and 42 of the terminal board 2.

j. Connect the PULSE terminal of the test set to terminal 46 and the PULSE GRD terminal to terminal 45 of terminal board 2.

k. Repeat the test as described in *d* through *h*, except operate the *talk-hold* switch of the second outdial-to-line trunk to the *talk* position.

l. Restore the *talk-hold* switch.

m. Restore all switches to normal on the test set.

n. Remove the connections between the PULSE and PULSE GRD test set terminals and terminals 45 and 46 of terminal board 2.

o. Replace the rear cover of the information desk.

48. Transmission Loss (Monthly)

a. Connect the power cables of the signal generator and the db meter to an ac power source. Allow the test sets to warm up for 15 to 20 minutes.

b. Make initial adjustments of the test sets in accordance with the instructions given in TM 11–2096.

c. Connect the output of the signal generator to the input of the db meter.

d. Adjust the output of the signal generator at or about 1,000 cycles until the db meter indicates 0 db. When this reading is obtained, disconnect the leads between the signal generator and the db meter.

e. Remove the rear panel of the information desk and connect the input terminals of the db meter to terminals 1 (T) and 2 (R) of terminal board 1.

f. Insert the operator's headset into the headset jacks.

g. Connect the output terminals of the signal generator to the TT and TR terminals of the operator's headset jacks.

h. Operate the *talk-hold* switch of the first selector level trunk to the *talk* position. The db meter should indicate between —1 dbm and —20 dbm.

i. Restore the *talk-hold* switch to normal.

j. Disconnect the input terminals of the db meter from terminals 1 and 2 of terminal board 1.

k. Disconnect the output terminals of the signal generator from the TT and TR terminals of the operator's headset jacks.

l. Connect the output terminals of the signal generator to terminals 1 and 2 of terminal board 1.

m. Connect the input terminals of the db meter to the RR and RT terminals of the operator's headset jacks.

n. Operate the MON switch.

o. Operate the *talk-hold* switch of the first selector level trunk to the *talk* position.

p. The amount of loss indicated by the db meter should be between 0 and .5 dbm.

q. Restore the *talk-hold* switch to normal.

r. Restore the MON switch to normal.

s. Disconnect the output terminals of the signal generator from terminals 1 and 2 of terminal board 1.

t. Disconnect the input terminals of the db meter from the RT and RR terminals of the headset jacks.

u. Disconnect the signal generator and db meter from the ac source.

v. Replace the rear panel of the information desk.

49. Operator's Headset (Monthly)

a. Transmitter Test.

(1) Connect the transmitter terminals (plug terminals TT and TR) to the TRANSMITTER and COMMON terminals on Test Set I–142, I–142–A, I–142–B, or Telephone Test Set AN/PTM–6.

(2) Operate D1 control of the test set to position 2.

(3) Operate TRANS D3 control of the test set to position 4.

(4) Test the transmitter by using a sound pressure of 10 dynes per square centimeter from the sound source of the test set.

(5) A reading of at least +2 db should be observed on meter M1 of the test set.

(6) Disconnect the leads from the test set and the transmitter terminals on the operator's headset.

(7) Restore the controls of the test set.

b. Receiver Test.

(1) Connect the operator's headset receiver terminals RR and RT to the RECEIVER and COMMON terminals of the test set.

(2) Operate REC D4 control of the test set to position 6.

(3) Test the receiver by using a sound pressure of 10 dynes per square centimeter from the sound source of the test set. A reading of at least 0 db should be observed on meter M1 of the test set.

(4) Disconnect the leads from the test set and the receiver terminals on the operator's headset.

(5) Restore the controls of the test set to normal.

50. Fuse Alarm Circuit (Weekly)

a. Remove the rear panel of the information desk.

b. Insert the metallic portion of a screwdriver between the fuse alarm bar and any fuse on the fuse panel.

c. Observe that the fuse alarm lamp lights.

d. Remove the screwdriver from the fuse panel. The fuse alarm lamp should go out.

Caution: **Do not allow the screwdriver to touch any grounded points when making the fuse alarm test.**

e. Replace the rear panel of the information desk.

Section VII. ATTENDANT'S SWITCHBOARD, ROUTINE TESTING

51. Connector Intercept, Information, Dead Selector Level Intercept, and Selctor O Level Trunk Tests (Monthly)

a. Remove the plug of the operator's headset from the headset jacks of the information desk.

Note. Omit the procedure in *a* above for selector O level trunks.

b. Request an assistant to monitor busy out, and insert the plug of a hand test telephone into the MON A jack of a trunk circuit plate to be tested.

(1) An incoming line and busy lamp on the attendant's switchboard should light.

(2) The line pilot lamp should also light.

Note. The multiple incoming line and line pilot lamps of each positional unit should light. For example, in a four-panel multiple, the indication appearing on panel 1 (positional unit 1) should be the same as that appearing on panel 5 (positional unit 2) and panel 9 (positional unit 3).

c. Insert the answer cord plug (at any positional unit) into the line jack associated with the trunk under test.

(1) The incoming line lamp and the line pilot lamp should go out.

(2) The answer cord supervisory lamp and the supervisory pilot lamp should flash momentarily.

d. Operate the associated TALK-MON switch to the TALK position.

e. Check for transmission between the attendant's switchboard and the hand test telephone.

f. After the transmission check has been made, request the assistant to remove the plug of the hand test telephone from the monitor A jack.

g. Test the remainder of the trunk circuits by following the procedure described in *b* through *f* above.

52. Common Battery Lines (Monthly)

a. Request an assistant to connect the alligator clips of a CB telephone to a common battery telephone line at the main distributing frame (MDF) and assign a line to receive test calls.

b. When the assistant lifts the receiver from the cradle, the incoming line lamp, busy lamp, and the line pilot lamp on the attendant's switchboard should light at each multiple appearance of the line.

c. Insert an idle answer cord plug into the associated line jack at any multiple appearance.

(1) The incoming line lamp and the line pilot lamp should go out.

(2) The busy lamp should remain lighted.

(3) The answer cord supervisory lamp and the supervisory pilot lamp should flash momentarily.

d. Insert the associated call cord plug into the jack associated with the line being called. The busy lamp, the call cord supervisory lamp, and the supervisory pilot lamp should light.

e. Restore the associated TALK-MON switch to normal (if operated).

f. Operate the RING REAR-RING FRONT switch to the RING FRONT position for about 1 second. When the call cord supervisory lamp goes out, the called party has answered.

g. Operate the TALK-MON switch to the TALK position. Inform the called party of the test in progress, and then instruct him to disconnect.

h. Restore the TALK-MON switch to normal.

i. When the called party disconnects, the call cord supervisory lamp and the supervisory pilot lamp should light.

j. When the assistant disconnects, the answer cord supervisory lamp should light.

k. Remove the call and answer cord plugs from the jacks. The call cord and answer supervisory lamps should go out.

l. Repeat the procedure in *a* through *k* above until each of the common battery lines has been tested.

53. Magneto (Local Battery) Lines (Monthly)

a. Request an assistant to connect the alligator clips of a LB telephone to a local battery line at the MDF.

b. When the assistant operates the hand generator on the LB telephone, the incoming line lamp, busy lamp, and the line pilot lamp on the attendant's switchboard should light at each multiple appearance of the line.

c. Follow the procedure described in 52*c* through *i*.

d. When the assistant rings off, the answer cord supervisory lamp should light.

e. Remove the call and answer cords from the jacks. The call cord and answer supervisory lamps should go out.

f. Repeat the procedure in *a* through *e* above until each of the common battery lines has been tested.

54. Cord Circuits

a. Cord Tests (Weekly). The T, R, and S leads of the call and answer cords are tested individually for opens and intermittent troubles. The condition of each cord circuit is determined by observing the cord circuit supervisory lamps and listening at the receiver of the operator's headset while shaking and moving the plug end of the cord. Repeat the following procedure for each call cord and for each answer cord.

(1) Insert the call (or answer) cord into the cord test jack, located on the piling rail of the right panel on odd numbered positional units only. The call (or answer) cord supervisory lamp should flash as the cord plug is inserted into the test jack.

(2) Operate the associated TALK-MON switch to the TALK position.

(3) Shake and move the cord plug without removing the plug from the jack. Clicks should *not* be heard in the operator's receiver and the supervisory lamp should *not* flash.

(4) When the call cord test is completed, restore the TALK-MON switch to normal and remove the cord plug from the test jack.

b. Cord Tests (Monthly)

(1) Temporarily mount a jack strip, prepared as described in (*a*) through (*c*) below, above the face equipment of the positional unit to be tested in order to simulate calls received at the attendant's switchboard.

(*a*) *Connections to jack 1.*

1. Connect one end of a test lead with a 300-ohm resistor in series to ground and connect the other end to the sleeve of jack 1.

2. Connect a CB telephone to the tip and ring of jack 1.

(*b*) *Connections to jack 2.*

1. Connect one end of a test lead with a 2,000-ohm resistor in series to ground and connect the other end to the sleeve of jack 2.

2. Connect a field type telephone (set for LB operation) to the tip and ring of jack 2.

(*c*) *Connections to jack 3.* Connect the PULSE terminal of the pulse speed and percent make test set to the ring of jack 3 and the PULSE GRD terminal of the test set to the tip of jack 3.

(2) Insert the plug of the operator's headset into the operator's headset jacks.

(3) Remove the handset from the cradle of the field type telephone.

(4) Insert the plug of an answer cord into jack 2. The answer cord lamp, supervisory lamp, and the supervisory pilot lamp should flash momentarily.

(5) Insert the plug of the associated call cord into jack 1. The call cord supervisory lamp and the supervisory pilot lamp should light.

(6) Momentarily operate the RING REAR-RING FRONT switch of the associated cords to the RING FRONT position. The CB telephone should ring.

(7) Remove the handset from the cradle of the CB telephone. The call cord super-

visory lamp and the supervisory pilot lamp should go out.

(8) Replace the CB telephone handset on the cradle. The call cord supervisory lamp the supervisory pilot lamps should light.

(9) Replace the field telephone handset on the cradle and ring off. The answer cord supervisory lamp should light.

(10) Remove the cords from jacks 1 and 2. The call cord supervisory lamp, the answer cord supervisory lamp, and the supervisory pilot lamp should go out.

(11) Remove the CB telephone handset from the cradle.

(12) Insert the plug of the call cord previously used into jack 1. The call cord supervisory lamp and the supervisory pilot lamp should flash momentarily.

(13) Insert the plug of the associated answer cord into jack 2. The answer cord supervisory lamp and the supervisory pilot lamp should *not* light.

(14) Momentarily operate the RING REAR-RING FRONT switch of the associated cords to the RING REAR position. The field telephone should ring.

(15) Remove the field telephone handset from the cradle.

(16) Operate the TALK REAR-TALK FRONT switch to the TALK REAR position.

(17) Operate the TALK-MON switch to the TALK position and check for transmission between the operator's headset and the field telephone.

(18) Operate the TALK REAR - TALK FRONT switch to the TALK FRONT position and check for transmission between the operator's headset and the CB telephone.

(19) Restore the TALK-MON and TALK REAR - TALK FRONT switches.

(20) Replace the field telephone handset on the cradle and ring off. The answer cord supervisory lamp and the supervisory pilot lamp should light.

(21) Replace the CB telephone handset on the cradle. The call cord supervisory lamp should light.

(22) Remove the cords from jacks 1 and 2. The answer cord supervisory lamp, the call cord supervisory lamp, and the supervisory pilot lamp should go out.

(23) Repeat the procedure as given in (1) through (22) above on all cord circuits.

c. Dial Test (Monthly).

(1) Prepare the pulse speed and percent make test set in accordance with the instructions contained in TM 11–2120.

(2) Insert the plug of a call cord into jack 3 (*b* above). The call cord supervisory lamp and the supervisory pilot lamp should light.

(3) Operate the TALK-MON switch to the TALK position.

(4) Perform the pulse speed test as described in TM 11–2120.

(5) Operate the WO (wipe out) switch.

(6) Reset the pulse speed and percent make test set to indicate the percent make of the dial on the positional unit.

(7) Reverse the leads to the tip and ring of jack 3. The call cord supervisory lamp and the supervisory pilot lamp should go out.

(8) Again reverse the leads to the tip and ring of jack 3. The call cord supervisory lamp and the supervisory pilot lamp should remain out.

(9) Remove the call cord from jack 3.

(10) Repeat the test procedure given in (1) through (9) above, using the answer cord instead of the call cord and observing the answer cord supervisory lamp instead of the call cord supervisory lamp.

(11) Restore the DIAL REAR switch.

(12) Repeat the procedure given in (1) through (11) above on all the cords.

(13) Disconnect the pulse speed and percent make test set from the tip and ring terminals of jack 3.

(14) Disconnect the CB and field type telephones from jacks 1 and 2, respectively.

Note. Retain the jack strip for future tests.

55. Operator's Circuits

a. Headset Test (Weekly).

(1) Insert the plug of the headset into the

left set of headset jacks on the shelf apron starting at the highest position.

(2) Shake and move the plug and cord (without removing the plug from the jack) while listening at the receiver. There should be no cutoffs or clicks.

(3) Insert an idle call cord into an idle out-dial-to-line trunk jack and dial the test desk number.

(4) Operate the TALK-MON switch to the TALK position and check for transmission.

(5) When the transmission test is completed, restore the TALK-MON switch and remove the call cord.

(6) Repeat the procedure given in (1) through (5) above for other positions, working progressively toward the lowest position.

(7) Repeat the procedure given in (1) through (6) above with the plug of the headset inserted into the right set of headset jacks.

(8) When the transmission test is completed, request the wire chief to stand by.

b. Position Switching Test (Weekly).

(1) Operate the position switching (POS SW) switch at the positional unit being tested.

(2) Disconnect the operator's headset from the headset jack at this position.

(3) Insert the plug of the operator's headset into either of the headset jacks of the preceding positional unit.

(4) Request the wire chief to check the quality of the transmission from this preceding positional unit.

(5) When the transmission test is completed, restore the TALK-MON switch and remove the call cord from the previous positional unit.

c. One-Way Interposition Trunk Test (Monthly).

(1) Insert an idle call cord into an idle one-way interposition trunk jack. The busy lamp associated with the interposition trunk jack being used (at the calling position) and the incoming line and the line pilot lamps associated with the interposition jack at the called position should light.

(2) Insert an idle call cord into the interposition jack associated with the lighted line lamp at the called position.

(*a*) The line and line pilot lamps should go out.

(*b*) The busy lamp (at the calling position) should remain lighted.

(3) Check for transmission between the headset at the calling position and the headset at the called position.

(4) When the transmission test is completed, remove the call cord from the interposition jack at the called position.

(*a*) The busy lamp at the calling position should go out momentarily.

(*b*) The supervisory cord and supervisory pilot lamps at the calling position should light.

(5) Remove the call cord from the interposition jack at the calling position. The supervisory lamps should go out.

(6) Repeat the procedure given in (1) through (5) above for each one-way interposition jack of the positional unit being tested.

d. Two-Way Interposition Trunk Test (Monthly).

(1) Repeat the procedure given in *c*(1) through (5) above for each of the two-way interposition jacks of the positional unit being tested.

(2) Observe the operation of the busy lamp at both the calling and the called positions.

e. Peg Count Meter Test (Weekly).

(1) Make a record of the count at each of the peg count meters on the relay rack associated with the operational unit of the attendant's switchboard being tested.

(2) Momentarily operate each of the PC switches a given number of times.

(3) Check at the relay rack to see that the count at each of the PC meters associated with the operational unit has advanced the given number of times.

(4) Repeat the procedure given in (1)

through (3) above at each positional unit.

f. Conference Jack Test (Weekly).

(1) Request two assistants to call the attendant's switchboard to test conference service.

(2) Insert an answer cord into each line jack when the line lamp lights and insert the associated call cord into a conference jack.

(3) Separately operate the TALK-MON switch associated with the cords and request the conference parties to check for transmission.

(4) Test for transmission at each conference jack by moving the call cords successively to different conference jacks until all jacks are tested.

(5) Notify the assistants when the tests are completed and remove the answer and call cords from the line and conference jacks, respectively.

56. Alarm Circuits

a. Night Alarm Test (Daily).

(1) Restore the night alarm (NA) switch, located at the first positional unit only, to the normal position (if operated).

(2) Request an assistant to call the attendant's switchboard. The buzzer should sound when the incoming line lamp and the line pilot lamp light.

(3) Insert an answer cord plug from any positional unit into the corresponding line jack.

(*a*) The buzzer should stop sounding.

(*b*) The incoming line lamp and line pilot lamp should go out.

(4) Request the assistant to hang up.

(*a*) The buzzer should sound.

(*b*) The supervisory pilot lamp should light.

(5) Disconnect the answer cord.

(*a*) The buzzer should stop sounding.

(*b*) The supervisory pilot lamp should go out.

(6) Repeat the procedure given in (2) through (5) above, using an answer cord from each positional unit of the switchboard.

b. Fuse Alarm Test (Weekly).

(1) Insert the metallic portion of a screwdriver between the fuse alarm bar and any fuse on the fuse panel. The fuse alarm lamp at the associated position and the MASTER FUSE ALM lamp on the first positional unit should light.

(2) Remove the screwdriver between the fuse alarm bar and fuse. The fuse alarm lamp and the MASTER FUSE ALM lamp should go out.

(3) Repeat the procedure given in (1) and (2) above for each position of the attendant's switchboard.

c. Fire Alarm Tests (Weekly). The fire alarm trunks are arranged either for automatic extension (B wiring) or manual extension (C wiring) of a call from a dial telephone to the fire department. Tests are conducted at the first positional unit of the attendant's switchboard.

(1) *Automatic extension.*

(*a*) Request an assistant to insert the plug of the hand test telephone into the test (TST) jack of a fire alarm trunk circuit plate mounted on the miscellaneous shelf. The assistant should hear ringing tone in the receiver of the hand test telephone, the associated alarm (red) lamp at the attendant's switchboard should light, and the fire alarm bell should sound.

(*b*) Operate the talk switch associated with the fire trunk used and listen over the receiver.

(*c*) When the fire department answers, the supervisory (white) lamp should flash briefly, the fire alarm lamp should go out, and the fire alarm bell should stop sounding.

(*d*) Inform the person answering that the fire trunk lines are being tested, that his cooperation is required while all the fire trunks are tested, and that he will be advised when the tests are completed.

(*e*) Request the called party to signal for call tracing. The fire alarm ringer should sound.

(*f*) Request the assistant to operate the CHK switch associated with the ringer. The ringer should stop.

(*g*) Request the fire department to disconnect. The supervisory (white) lamp should light.

(*h*) Request the assistant to remove the plug of the hand test telephone from the TST jack. The supervisory lamp should go out.

(*i*) Operate the DIAL RLS switch associated with the alarm trunk. The fire alarm ringer should sound.

(*j*) Request the assistant to restore the CHK switch. The ringer should stop.

(*k*) Restore the DIAL RLS and talk switches.

(*l*) Repeat the procedure above until all automatic extension fire alarm trunk circuit plates have been tested.

(*m*) Notify the fire department of completion of tests.

(2) *Manual extension.*

(*a*) Follow the procedure as described in (1) (*a*) and (*b*) above.

(*b*) Operate the fire switch associated with the fire alarm trunk at the attendant's switchboard. Ringing should be heard in the operator's headset.

(*c*) Follow the procedure as described in (1) (*c*) through (*j*) above.

(*d*) Restore the DIAL RLS switch.

(*e*) Momentarily operate the FA RLS switch.

(*f*) Restore the talk switch.

(*g*) Repeat the procedures given in (*a*) through (*f*) above until all manual extension fire alarm trunk circuit plates have been tested.

(*h*) Notify the fire department of completion of the fire alarm trunk tests.

Section VIII. MISCELLANEOUS EQUIPMENT, ROUTINE TESTING

57. Distributing Frames and Grading Panels (Semiannually)

The distributing frames and grading panels require very little maintenance. Maintenance will consist of cleaning components, checking for loose or broken connections, and inspecting heat coils for operation.

a. Clean the distributing frames and grading panels with a bristle brush or a vacuum suction tool.

b. Inspect wiring, cabling, and jumpers for signs of chafing and deteriorated insulation. Check all soldered connections for looseness and granular condition.

c. Check all nuts and bolts for looseness; tighten any loose nut or bolt, being careful not to strip the threads.

d. Check for operated heat coils on the distributing frames; make certain that all the heat coils are properly engaged in mounting springs.

e. Examine telltale lamps on the distributing frames for looseness in sockets; check their operation.

f. Inspect the connector plug (test shoe) of the test cable on the distributing frames. Clean and adjust the contacts, if necessary.

g. Inspect for loose, broken or improperly alined terminal boards.

h. Inspect for improper alinement of lightning arrestors and heat coils on the protector strips of all distributing frames.

i. Inspect the jumper wires for the following:

(1) Unreliable splices in wires.

(2) Wrong type of wire.

(3) Insufficient or excessive slack (should be 1 to 3 inches).

(4) More than one twist in back of the fanning strip.

(5) Incorrect routing through rings and fanning strips.

(6) Dead wires which are not removed.

(7) Reversed color codes (should be black to tip and red to ring).

(8) Excessive amount of solder on terminals.

(9) More than one turn on lug.

(10) Insulation stripped too far back on wire.

58. Portable Test Equipment (Monthly)

a. Hand Test Telephone. A routine test of the hand test telephone should include three individual tests. Perform each test in accordance with the instructions given in TM 11–2120.

(1) A dial test using the pulse speed and percent make test set.

(2) A resistance and continuity test using the multimeter.

(3) A transmitting efficiency test using a first selector circuit of the central office.

b. Pulsing Limits Test Set. A routine test of the pulsing limits test set should include two individual tests. Perform each test in accordance with the instructions given in TM 11–2120.

(1) A dial test using the pulse speed and percent make test set.

(2) A continuity test using Multimeter TS–352/U or equivalent.

c. Pulse Speed and Percent Make Test Set. A routine test for the pulse sped and percent make test set is contained in TM 11–2120. This test includes:

(1) The checking of full scale and preset circuits.

(2) The pulse speed and percent make circuits.

d. XY Switch Test Set. A routine test of the XY switch test set is contained in TM 11–2120. The test equipments required to routine the XY switch test are listed below.

(1) A multimeter for making resistance measurements.

(2) A Stromberg-Carlson type 6–B current flow test set for making releasing tests of the timing relays.

(3) A pulse speed and percent make test set for checking the pulse source circuits.

e. Connector Routine Test Circuit Plate. A routine test of the connector routine test circuit plate is contained in TM 11–2120. The test equipments required to routine the connector routine test circuit plate are listed below.

(1) A multimeter for making resistance measurements.

(2) A hand test telephone to perform operational tests.

(3) A Stromberg-Carlson type 6–B current flow test set for testing the operaeration of the relays.

f. Circuit Plate Maintenance Test Set.

(1) Routine tests of the circuit plate maintenance test set are contained in TM 11–2120. These tests include:

(*a*) The full scale and meter preset circuits test.

(*b*) The dial test.

(*c*) Meter pulsing circuits test.

(*d*) Continuity circuits test.

(*e*) Miscellaneous circuits test.

(2) The test equipment required for these tests are—

(*a*) Multimeter for making resistance measurements.

(*b*) Stromberg-Carlson type 6–B current flow test set for testing the operation of the relays.

(*c*) Test Set TS–190/U for checking continuity.

(*d*) Pulse speed and percent make test set for testing the dial.

59. Emergency Power (Weekly)

a. Start the emergency power source.

b. Allow the unit to run for 15 minutes to warm up.

c. Transfer the central office from the commercial power source to the emergency power source.

d. Observe the emergency power source for proper operation under load conditions.

e. Transfer the central office load to the commercial power source.

f. Stop the emergency power source.

CHAPTER 4
SWITCHES

Section I. GENERAL

60. Types of Switches

The XY dial central office equipment includes six types of switches: XY switch, rotary switch, minor switch, lever switch, turn switch, and push switch. Maintenance data for each of these switches is described in a separate section of this chapter.

61. Test Equipment and Tools

a. Test Equipment. The test equipment used to check the operation of the switches is described in TM 11–2120.

b. Tools Supplied. The tools supplied by the manufacturer for maintenance of the switches are listed below. Tools required, but not supplied by the manufacturer, are listed in TM 11–2120.

Manufacturer's tool No.	Tool	Function
66	Spring adjuster	Adjusting heavy springs of A and C type relays.
72	Adjusting tool	Adjust light springs of A and C type relays.
79	End wrench	Removes hex head screws.
82	Allen wrench, 1 set of 3.	Releases or tightens set screws.
83	Truarc pliers	Removes and replaces Truarc retaining rings.
85	Spring adjuster	Bend Y armature assembly (up).
86	Spring adjuster	Bends X armature assembly.
88	Spring adjuster	Adjusts feet of wiper carriage.
89	Spring adjuster	Bends release magnet armature.
93	Split 6-inch screwdriver.	For holding and starting screw.
95	Cable clip pliers	Secures cable clip to Y carriage.
96	Locking pliers.	
97	Cable clip pliers.	
99	Interrupter adjusting pliers.	Adjusts position of interrupter bumper.
102	Push-pull gram gage.	Measures contacts spring pressure.
90	Spring adjuster	Bends Y armature assembly (down).
75	End wrench	To remove ¼ inch and ⅜ inch nuts.

Section II. DESCRIPTION OF XY SWITCH

62. XY Switch Records

The universal XY switch can be used interchangeably without modification as the switching mechanism of a linefinder, selector, or connector. In an operating central office, switches that are removed from service for adjustment or repair are replaced by a switch from a common pool and tend to lose their identity. To maintain the identity of each switch for trouble and maintenance records, the following procedure is recommended:

a. Arbitrarily assign a number to each XY switch in the central office. Stencil the number on the turned-up lip at the front of each mechanism plate.

b. Establish a numerical card file with a card for each switch.

c. Enter the following current information on the cards:

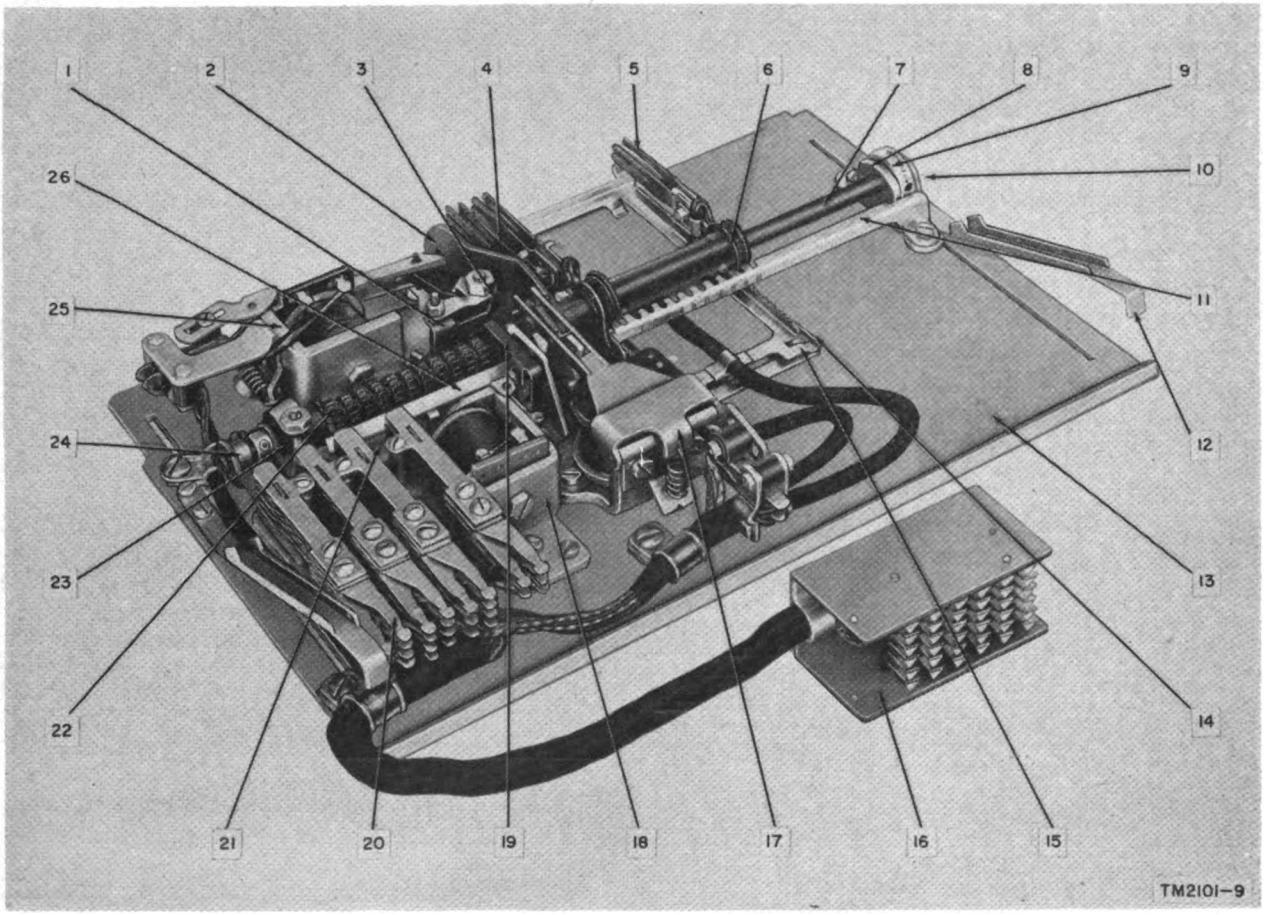
(1) Location of switch (bay, shelf, and circuit number).

(2) Dates and reasons for removal and replacement in service.
(3) Adjustments and repairs made.
(4) Lubrication dates.
(5) Any other information which will aid the maintenance program.

63. Nomenclature and Function of Assemblies and Parts

The assemblies and parts of the XY switch (fig. 9) are discussed below. Each assembly and part is described, its function noted, and its location specified and illustrated. To orient the XY switch, face the turned-up lip of the mechanism plate to the front. This will place the three locating lugs of the mechanism plate at the back, and thus orient the right and left sides of the XY switch.

a. Mechanism Plate (fig. 10). The mechanism plate (10) is the mounting plate for all components of the XY switch. The components are fastened to the mechanism plate by machine screws. Except for the cable clip screws used in fastening the cable clips on the mechanism



1 X retaining pawl assembly
2 Cog roller support
3 X gear assembly
4 XX–X rack assembly
5 Spring wiper assembly (3)
6 Pinion assembly
7 Tubular shaft assembly
8 Right yoke
9 Digit drum
10 Y return spring assembly
11 Guide rule
12 Lockspring (2)
13 Mechanism plate
14 X carriage assembly
15 X carriage
16 Cable assembly
17 Y magnet assembly
18 Release magnet assembly
19 Y retaining pawl assembly
20 Spring combination assembly
21 Switching level
22 Cog roller assembly
23 Bearing support
24 Cam assembly
25 X magnet assembly
26 Y stop bar assembly

Figure 9. XY switch, major assemblies and parts.

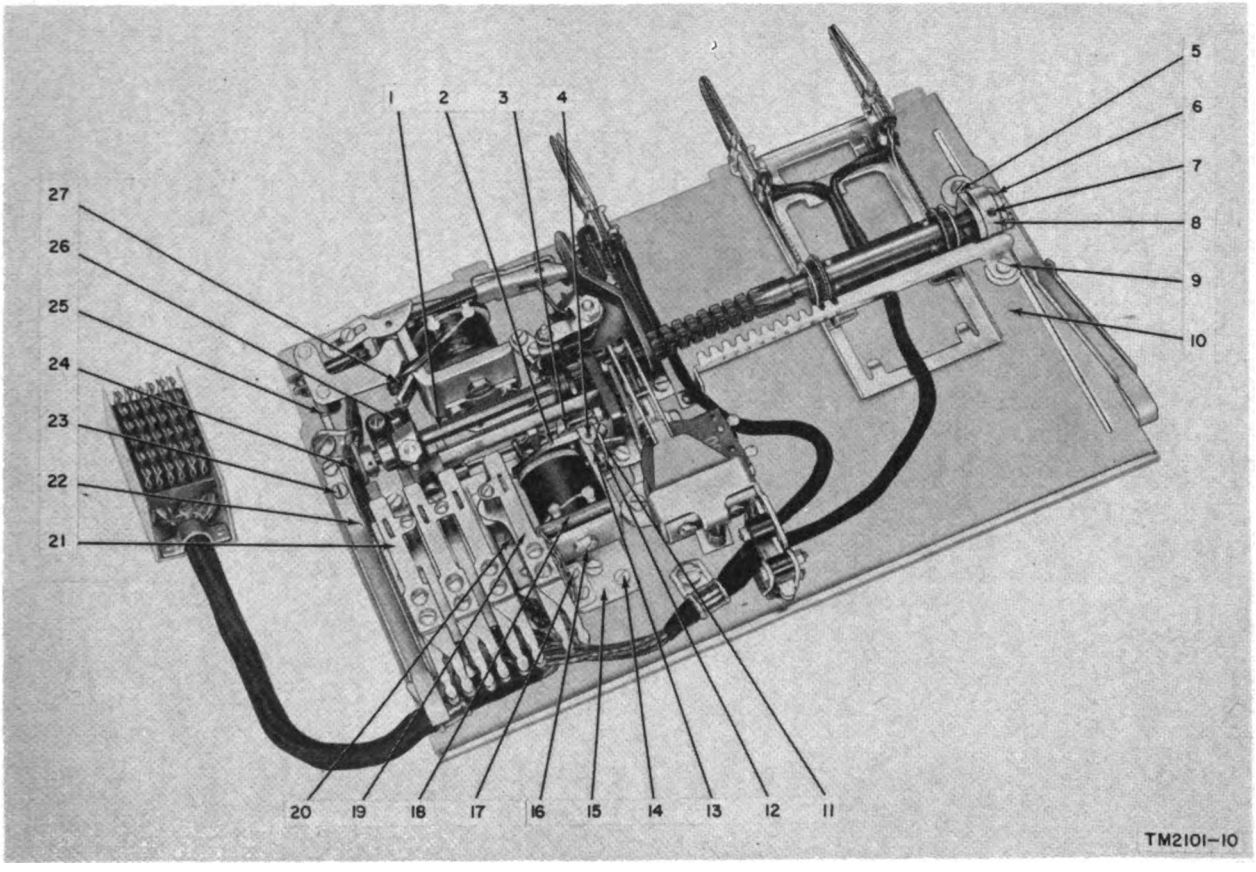
plate, all screws are of the binding-head type. The binding-head screws lock in place when driven home securely.

b. Lockspring (fig. 10). The two interchangeable locksprings (22) are fastened to the right and left sides of the mechanism plate by two lockspring mounting screws (23). The locksprings secure the XY switch in the switch bank (or cell).

c. Right Yoke (fig. 10). The right yoke (6) is located adjacent to the right lockspring, and is fastened to the mechanism plate by two right yoke mounting screws (5 and 9). The right yoke serves as a mounting for the Y return spring and digit drum (8).

d. Bearing Support (fig. 11). The bearing support (9) is located approximately 1½ inches from the left side of the mechanism plate and is fastened by two bearing support mounting screws (8). The bearing support serves as a mounting or the tubular shaft assembly.

(1) The Y limit cam (7) is fastened to bearing support by the Y stop screw (5) and locknut (6). The Y limit cam



1 Tubular shaft
2 Release magnet armature
3 Hinge bracket screw (2, 8–36 x 3/16 inch)
4 Hinge pin
5 Right yoke mounting screw (rear, 4–40 x ¼ inch)
6 Right yoke
7 Digit drum set screw (2, 6–40 x ⅛ inch)
8 Digit drum
9 Right yoke mounting screw (front, 4–40 x 5/32 inch)
10 Mechanism plate
11 Hinge bracket
12 Bracket mounting screw (2, 8–36 x 3/16 inch)
13 Hinge plate
14 Release magnet assembly mounting screw (2, 4–40 x 7/32 inch)
15 Release magnet frame
16 Coil mounting screw (8–36 x ¼ inch)
17 Spring combination mounting screw (2, 4–48 x 5/32 inch)
18 Release magnet coil
19 Spring combination
20 Spring combination assembly mounting screw
21 Spring combination assembly
22 Lockspring (2)
23 Lockspring mounting screw (4, 4–40 x 5/32 inch)
24 Plug key
25 Interrupter clamp
26 Y stop
27 Retractile spring

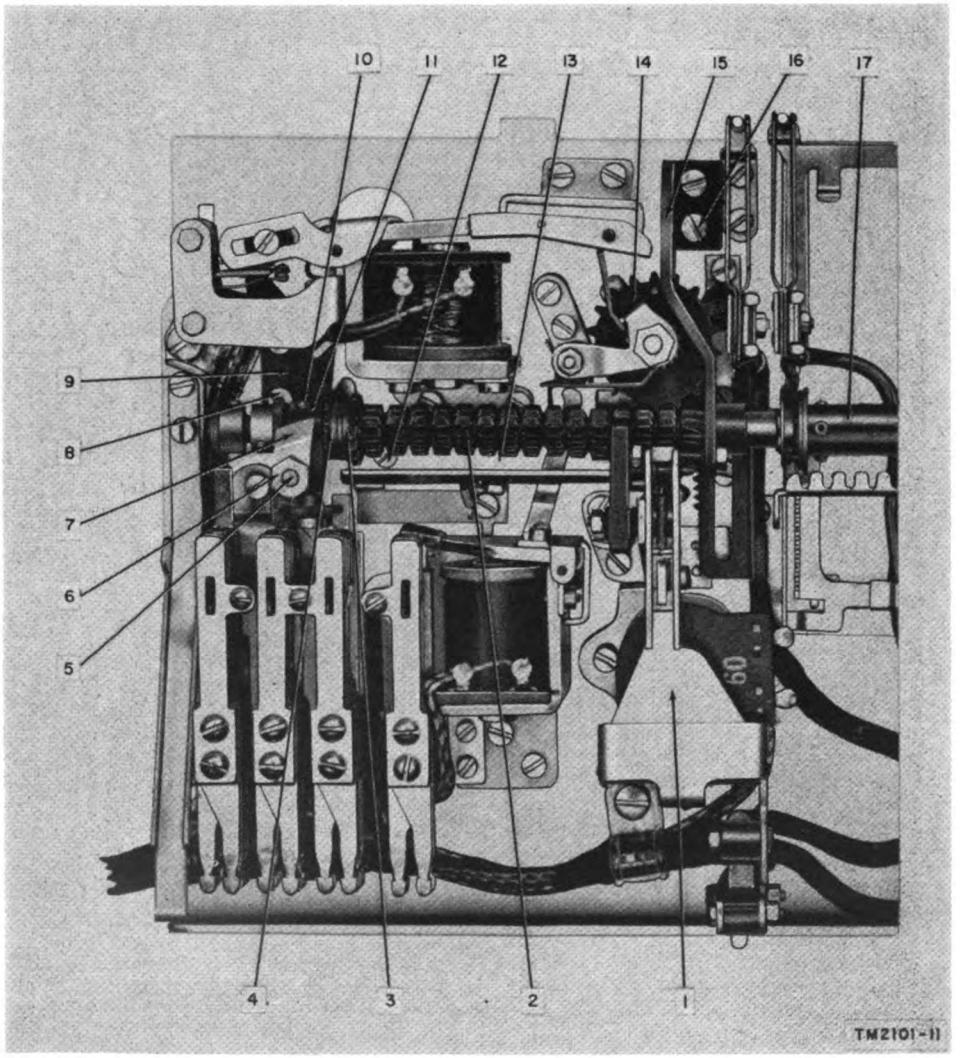
Figure 10. XY switch, front view (off normal position).

prevents further rotation of the cog roller after passing the overflow position, a part of the Y-overflow limiting action.

(2) The Y stop screw is fastened to the bearing support by the same locknut which fastens the Y limit cam. The Y stop screw prevents further travel of the cog roller when the switch is returned to the normal position.

e. Tubular Shaft Assembly. The tubular shaft assembly (7, fig. 9) is supported on the right by the right yoke (6, fig. 10) and on the left by the bearing support (9, fig. 11). The tubular shaft assembly consists of the parts listed below.

(1) *Tubular shaft.* The 10-inch long tubular shaft (1, fig. 10) contains a keyway slot approximately 3 inches long. The left end of the shaft contains an



1 Y armature assembly
2 Cog roller
3 Cog roller keys
4 Truarc retaining ring
5 Y stop screw (2, 6–40 x 1 1/16 inch)
6 Lock nut
7 Y limit cam
8 Bearing support mounting screw (2, 6–40 x 3/16 inch)
9 Bearing support
10 Stop collar set screw (2, 6–40 x 1/8 inch)
11 Stop collar
12 Way screw (2)
13 Switching lever
14 X gear assembly
15 Cog roller support
16 Cog roller support screw (2, 4–40 x 5/32 inch)
17 Pinion assembly

Figure 11. XY switch, top view (left side).

identification notch which serves to orient the shaft in position during assembly. The cog roller (2, fig. 11), pinion assembly (17), cam assembly (24, fig. 9), and digit drum (8, fig. 10) are mounted on the shaft.

(2) *Y stop.* The Y stop (26) is a T-shaped flat steel strip that is fitted into the left end of the shaft keyway. The long portion of the T is approxmiately at right angles to the shaft, and is used with the Y limit cam (7, fig. 11) for Y-normal adjustment and Y-overflow limiting action. The Y stop is securely fixed in position by the combined locking action of the stop collar (11), stop collar setscrew (10) and plug key (24, fig. 10).

(3) *Stop collar.* The stop collar is slotted and locks the Y stop, locking the stop into the left end of the tubular shaft keyway.

(4) *Plug key.* The plug key is inserted into the left end of the tubular shaft, fixing the Y stop in place.

(5) *Stop collar setscrew.* After assembly of the Y stop, stop collar, and plug key, the stop collar setscrew in the stop collar serves to secure the parts listed in (2) through (4) above to the tubular shaft.

f. Cog Roller Assembly. The cog roller assembly (22, fig. 9) is mounted to the tubular shaft assembly (7); this permits the roller to slide left and right and to rotate forward and backward. This action moves the wipers in the X and Y directions. The cog roller is stepped in the X direction (toward the digit drum) by the rotation of the X gear assembly (14, fig. 11). The cog roller assembly is rotated, for Y direction stepping, by the action of the Y magnet assembly (17, fig. 9). The sliding movement and rotation of the cog roller assembly controls the position of the pinion assembly (6). The cog roller assembly consists of the parts listed below:

(1) *Cog roller.* The cog roller (2, fig. 11) contains annular teeth that engage the X gear assembly (14) and serrated teeth that engage the Y retaining pawl assembly (19, fig. 9). To the left of the serrated portion is the ratchet gear which engages the Y stop bar assembly (26). The X carriage assembly (14) and pinion assembly (6) are mounted on the sleeve portion of the cog roller.

(2) *Cog roller keys.* Three cog roller keys (3, fig. 11) fasten the cog roller assembly on the tubular shaft.

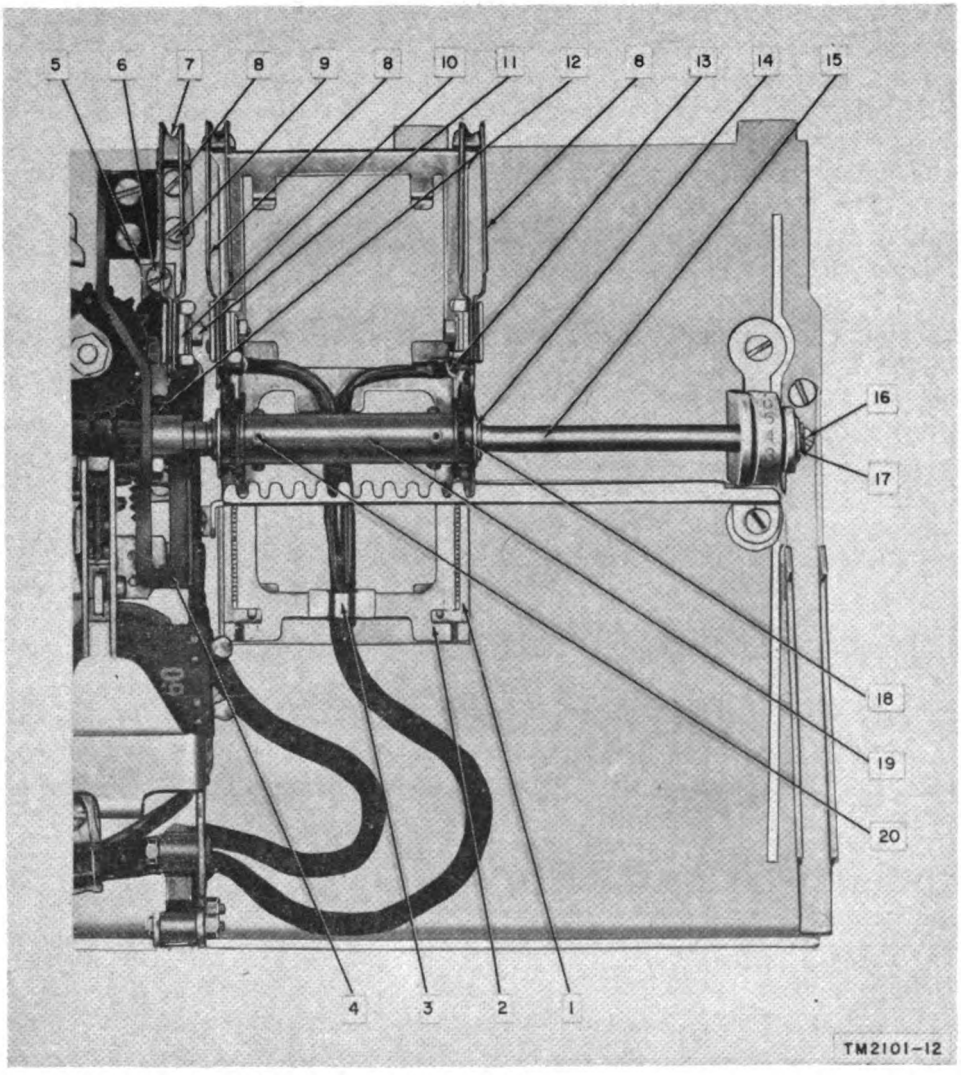
(3) *Truarc retaining ring.* The Truarc retaining ring (4) fastens the cog roller and cog roller keys to the tubular shaft assembly.

g. Cog Roller Support (fig. 11). The cog roller support (15) is fastened to the mechanism plate by two cog roller support screws (16). The cog roller support maintains the cog roller (2) in the proper operating position during stepping action. The cog roller also mounts the Y ejector (2, fig. 14) by means of the Y ejector bolt and nut (1 and 3). The Y ejector bushing is a guide for the Y drive pawl.

h. X Carriage Assembly (fig. 12). The X carriage assembly (1) is fastened on the sleeve portion of the cog roller assembly by the pinion assembly (19). The X carriage assembly rides on two bearings (18) attached to the carriage by Truarc retaining rings (14) and slides over the open portion of the mechanism plate from left to right.

i. Pinion Assembly (fig. 12). The pinion assembly (19) is positioned on the sleeve portion of the cog roller assembly between the bearing surfaces of the X carriage assembly (1) and held in place by six pinion setscrews (20). When the cog roller assembly rotates, the pinion assembly moves the Y carriage (2) in the Y direction (forward over the rear edge of the mechanism plate). The pinion gear teeth fit into the teeth of the Y carriage. As the pinion assembly rotates, the pinion gears (acting on the teeth of the Y carriage) slide the Y carriage in the Y direction. When the pinion gears are restored to their original position, the Y carriage is returned to normal.

j. Y Carriage (fig. 12). The Y carriage (2) rides within the X carriage assembly (1). The Y carriage moves the attached spring wiper assemblies (8) in the Y direction. As the Y carriage slides in the Y direction, the four spring wipers make contact with the wire bank leads associated with each switch. The wiper



1 X carriage assembly
2 Y carriage
3 Cable clip
4 XX–X rack
5 XX–X rack base
6 Base mounting screw (2, 4–40 x 5/32 inch)
7 XX–X pillar assembly
8 Spring wiper assembly (3)
9 XX–X pillar assembly mounting screw (2, 4–40 x 5/32 inch)
10 Spring wiper spacer
11 Spring wiper nut (3)
12 Rack way screw (2)
13 Cable clamp (3)
14 Truarc retaining ring (2)
15 Tubular shaft assembly
16 Y return spring assembly
17 Y return spring lockscrew (6–40 x 5/32 inch)
18 Bearing (2)
19 Pinion assembly
20 Pinion set screw (6, 6–40 x 1/8 inch)

Figure 12. XY switch, top view (right side).

leads are fastened to the Y carriage by a crimped cable clip (3).

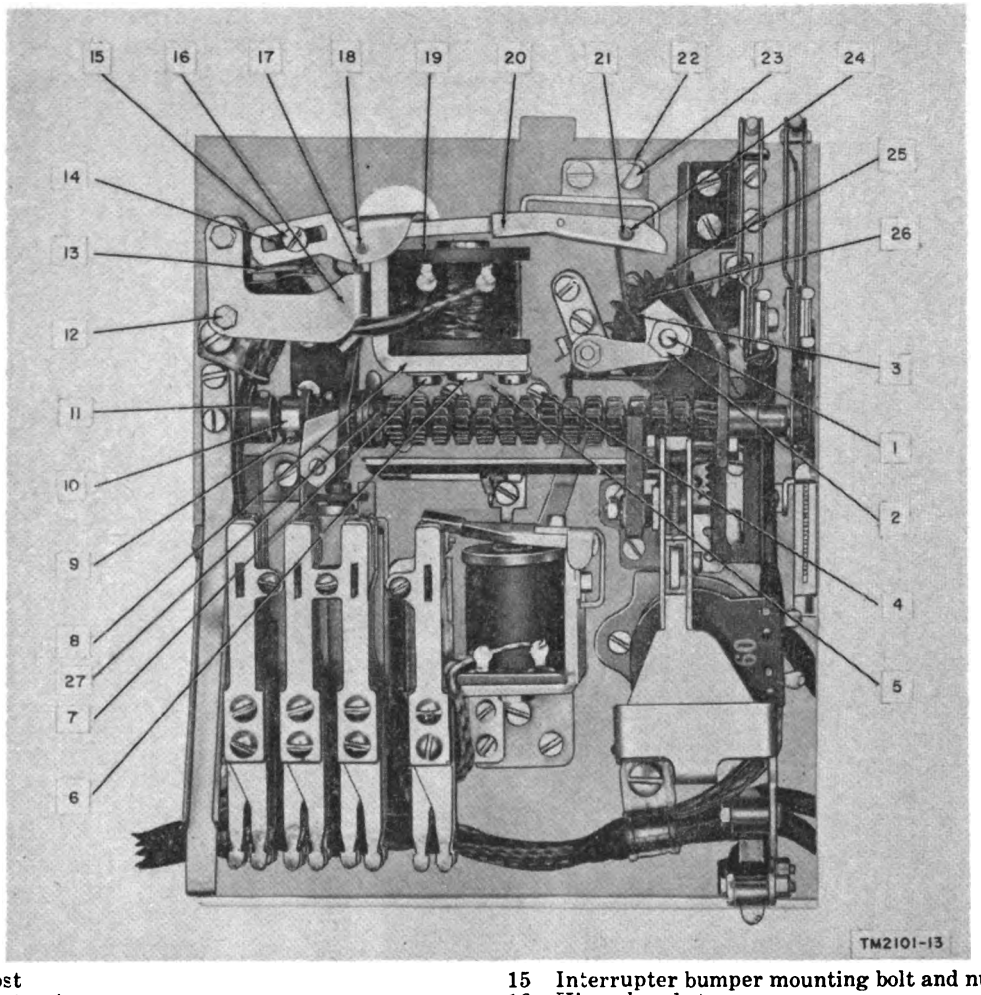
k. Spring Wiper Assembly (fig. 12). Two of the spring wiper assemblies (8) are attached to the Y carriage (2) and the third to the arm of the XX–X rack (4). The terminal ends of the spring wipers are connected by wire leads from the cable assembly. The leads are attached to the spring wipers and fastened in place by a cable clamp (13). The Y carriage spring wiper assemblies are identified as the tip (T) and ring (R) wipers (located on the left side of the Y carriage), and the sleeve (S) and helping sleeve (HS) wipers (located on the right side of the Y carriage).

l. Digit Drum (fig. 10). The digit drum (8) is fastened to the tubular shaft assembly (which passes through the digit drum and right yoke)

by two digit drum setscrews (7). The numbers 1 through 0 are stamped in vertical order into the surface of the digit drum. These numbers indicate the number of steps the pinion assembly moves the wipers in the Y direction. When 11 steps have been taken in the Y direction, the numbers can not be seen.

m. Cam Assembly (fig. 13). The two identical cams located at the extreme left position on the tubular shaft assembly comprise the cam assembly and are each fastened to the tubular shaft assembly by two cam setscrews (9). They are used to release the Y off-normal spring assembly and to operate the X–Y overflow spring assembly. They are identified as the Y off-normal cam (10) and the X–Y overflow cam (11).

n. Y Return Spring Assembly (fig. 12). The Y return spring assembly (16) is inserted into the right end of the tubular shaft assembly

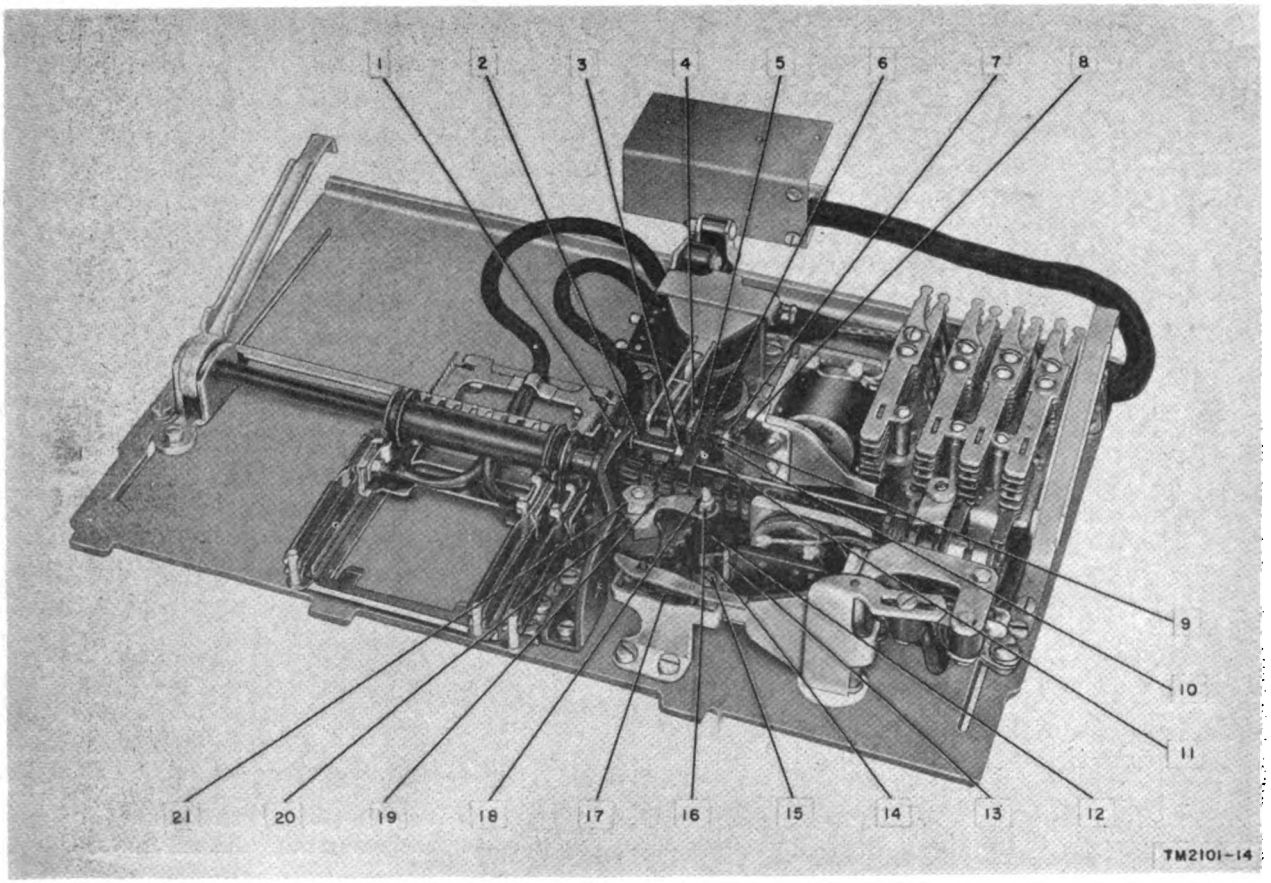


1 X gear post
2 X gear post nut
3 X drive pawl
4 X magnet assembly mounting screws (2, 4–40 x 5/32 inch)
5 X magnet mounting bracket
6 Coil mounting screw (Hex 8–36 x 1/4 inch)
7 Bracket mounting screw (2, 4–48 x 5/32 inch)
8 X magnet frame
9 Cam set screw (4, 6–40 x 1/8 inch)
10 Y off-normal cam
11 X–Y overflow cam
12 Interrupter assembly mounting bolt and nut (2)
13 Interrupter assembly
14 Interrupter bumper and bearing
15 Interrupter bumper mounting bolt and nut (2)
16 Hinge bracket
17 Hinge bracket mounting screw (2, 4–48 x 5/32 inch)
18 Hinge pin
19 X magnet coil
20 X armature assembly
21 Pawl pin
22 Armature backstop
23 Armature backstop mounting screw (2, 4–40 x 5/32 inch)
24 Lock ring (2)
25 Windup washer locking screw (6–38 x 1/8 inch)
26 X gear cluster
27 Y stop ratchet gear

Figure 13. XY switch, top view (left side).

(15), providing the mechanical force necessary to return the XY switch to the Y normal position. The assembly is locked into position by the Y return spring lock screw (17), located directly below the driving head of the Y return spring assembly.

o. X Gear Assembly (fig. 13). The X gear assembly is located on the rear center portion of the mechanism plate. When the X drive pawl (3) engages the ratchet gear, the X gear assembly is rotated through one step in the X direction. This action causes three additional actions to occur. The teeth of the sprocket gear engage the annular teeth of the cog roller assembly (22, fig. 9) and the bell cup gear engages the teeth that are a part of the XX–X rack assembly (4) moving the cog roller assembly one step in the X direction and the XX–X rack assembly one step in the Y direction. The X gear assembly releases the switching lever (13, fig. 11) during the first step taken in the X direction. The switching lever is moved to the right by the action of the toggle lever which breaks the contact springs of the X off-normal spring pileup. The X retaining pawl (19, fig. 14) engages the ratchet gear, maintaining the position of the ratchet gear until the X stepping action is re-



1 Y ejector bolt
2 Y ejector bushing
3 Y ejector nut
4 Y retaining pawl base
5 Y retaining pawl washer
6 Y retaining pawl
7 Y retaining pawl nut
8 Y retaining pawl post
9 Y retaining pawl spring
10 Y retaining pawl bushing
11 Y retaining pawl assembly mounting screw (2, 4–40 x 3/32 inch)
12 Bushing
13 X retaining pawl assembly base
14 X retaining pawl spring
15 X retaining pawl assembly base screw (2, 4–40 x 3/32 inch)
16 X retaining pawl post nut
17 X drive pawl spring
18 X retaining pawl post
19 X retaining pawl
20 Ejector strap
21 X gear post nut

Figure 14. XY switch, rear view.

peated. The X gear assembly consists of the parts listed below.

(1) *X gear cluster.* The X gear cluster (26, fig. 13) consists of ratchet, sprocket, and bell cup gears, silver-soldered together to form one part.

(2) *X ratchet bushing (upper).* The X ratchet bushing (upper) (42, fig. 17) fits into the X gear cluster, providing a bearing surface for movement of the X gear cluster.

(3) *X ratchet bushing (lower).* The X ratchet bushing (lower) (41) fits into the X return spring, providing a bearing surface for the X gear post (39).

(4) *X return spring.* The X return spring (43) is held in position at one end by the clip on the windup washer (44) and at the other end by the mounting hole on the X gear cluster. When the assembly is stepped in the X direction, the spring is placed under additional tension. When released, it returns the X gear assembly to the X normal position.

(5) *Windup washer.* The windup washer has eight notches at its outer periphery. When turned, the windup washer winds the X return spring to its proper tension. After adjustment, the windup washer is held in place by the windup washer locking screw (25, fig. 13).

(6) *X gear post.* The X gear post (1, fig. 13) and X gear post nut (2) fasten the X gear assembly to the mechanism plate. In addition, these parts fasten one end of the ejector strap (20, fig. 14).

p. X Retaining Pawl Assembly (fig.9). The X retaining pawl assembly (1) is located just to the left of the X gear assembly (3). The X retaining pawl (19, fig. 14) engages the X gear assembly at the end of each step taken in the X direction, retaining it in that position. The X retaining pawl assembly consists of the parts listed below.

(1) *Ejector strap.* The ejector strap (20) is fastened at one end by the X gear post nut (21) and at the other end by the X retaining pawl post and nut (16 and 18). The ejector strap is a guide for the X drive pawl (3, fig. 13) when operated and is a rest when not operated.

(2) *X retaining pawl assembly base.* The X retaining pawl assembly base (13, fig. 14) is fastened to the mechanism plate by two X retaining pawl assembly base screws (15). The assembly base is a mounting surface for the other parts of the X retaining pawl assembly.

(3) *X retaining pawl.* The X retaining pawl (19) is fastened by the X retaining pawl post and X retaining pawl post nut. The X retaining pawl holds the X gear assembly in its off-normal position and is released when the release magnet armature (2, fig. 10) strikes the lower end of the X retaining pawl.

(4) *X retaining pawl spring.* The X retaining pawl spring (14, fig. 14) is located over the bushing (12). It provides the spring tension which operates the X retaining pawl. One end of the spring is fastened by the notched arm in the ejector strap and the other end fits against the X retaining pawl.

(5) *Bushing.* The bushing mounts the X retaining pawl spring. It fits between the two arms of the X retaining pawl.

(6) *X retaining pawl post.* The X retaining pawl post mounts the parts of the X retaining pawl assembly.

q. Switching Lever (fig. 11). The switching lever (13) is located directly below the cog roller (2). It is fastened to the mechanism plate with two way screws (12) which permit the switching lever to slide both left and right. During the first step taken in the X direction, the first post on the X gear assembly (located directly below the sprocket gear) moves away from the elevated arm of the switching lever. This action releases the toggle lever of the spring combination assembly (20, fig. 9) which rides in the square hole in the switching lever, sliding the lever in the left direction. When the switch moves to the X overflow position, the second post on the X gear assembly (directly opposite the first) moves against the notch in the elevated arm, sliding the switching lever to its ex-

treme left position. This action operates the toggle lever of the spring combination assembly. When the switch is returned to its normal position, the first post of the X gear assembly moves back against the elevated arm, returning the switching lever to its normal position on the mechanism plate and restoring the toggle lever to its normal position.

r. X Magnet Assembly (fig. 9). The X magnet assembly (25) is located in the left-rear corner of the mechanism plate (13). When the X magnet assembly operates, the X drive pawl (3, fig. 13) engages the ratchet gear of the X gear assembly, rotating it one step. At the same time, the contact springs of the interrupter assembly (13) are released. When the X magnet assembly is released, the tension on the retractile spring (27, fig. 10) is relieved, returning the X armature assembly to the armature backstop (22, fig. 13) and placing the drive pawl at the rest position on the ejector strap. The X magnet assembly consists of the parts listed below.

(1) *X magnet mounting bracket.* The X magnet mounting bracket (5) is fastened to the mechanism plate by two X magnet assembly mounting screws (4) and provides a mounting for the X magnet frame (8).

(2) *X magnet frame.* The L-shaped X magnet frame is fastened to the X magnet mounting bracket by two bracket mounting screws (7) and provides a mounting surface for the X magnet coil and hinge bracket (16).

(3) *Hinge bracket.* The irregularly shaped hinge bracket is fastened to the X magnet frame by two hinge bracket mounting screws (17). The hinge bracket mounts the interrupter assembly (13), secures one end of the retractile spring, and hinges the X armature assembly (20).

(4) *Interrupter assembly.* The interrupter assembly is fastened to the hinge bracket by two interrupter assembly mounting bolts and nuts (12). The interrupter assembly is a molded unit, consisting of a metal stop and two contact springs. Normally held in their make (closed) position, the contact springs open each time the X magnet assembly operates.

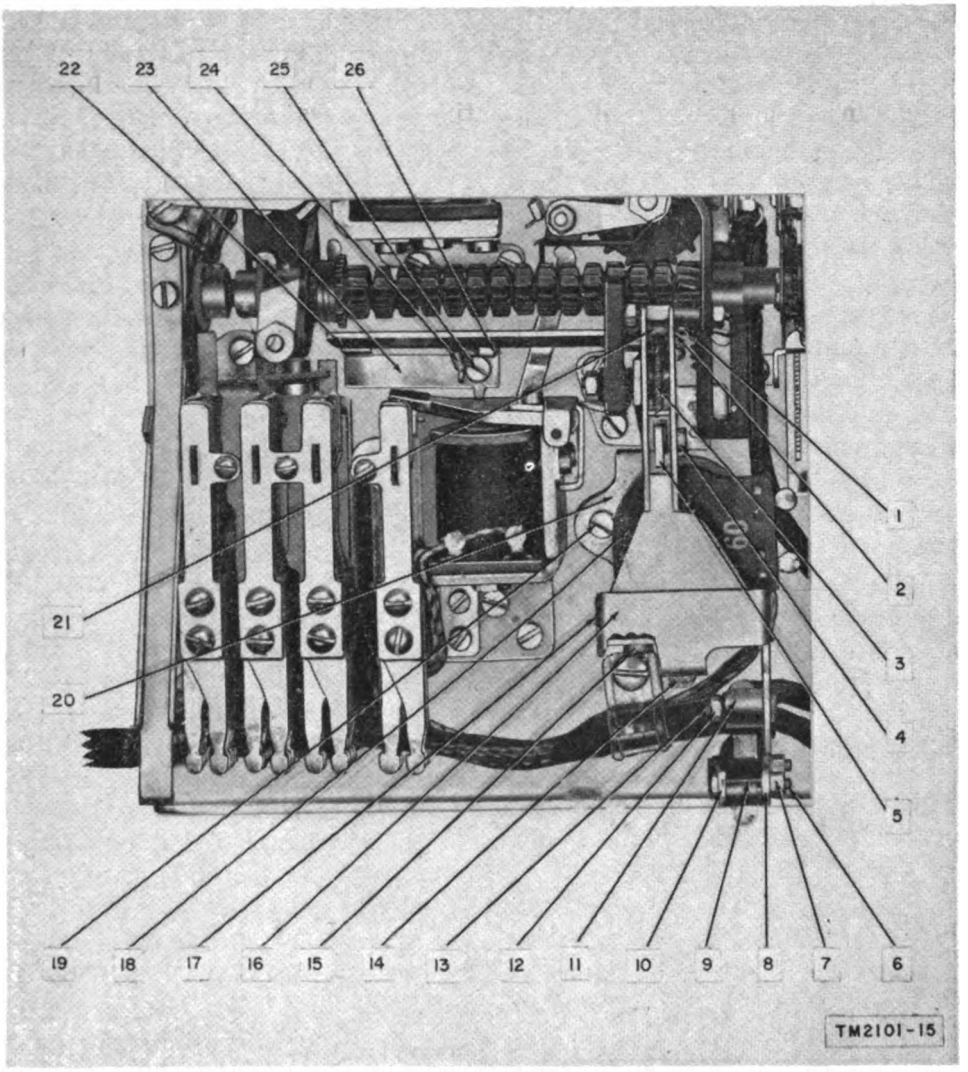
s. Y Stop Bar Assembly (fig. 9). The Y stop bar assembly (26) is located directly forward of the cog roller assembly (22). The two feet of the Y stop bar (22, fig. 15) are engaged by two square holes in the mechanism plate, held in the Y normal position by the stop bar return spring (24) and fastened to the foot retainer (26). The stop bar is actuated by the turned-up lip (cam) of the Y armature assembly (16). When the Y armature assembly operates, the cam moves against the stop bar roller (7, fig. 21), driving the stop bar toward the cog roller assembly. This action is completed when the Y stop bar (22, fig. 15) is engaged by the Y stop ratchet gear, limiting the travel of the cog roller assembly to one step in the Y direction for each operation of the Y magnet assembly. The Y stop bar assembly consists of the parts listed below.

(1) *Foot retainer.* The foot retainer is fastened to the mechanism plate by the stop bar backstop mounting screw (25). The turned-up lip of the retainer serves as a rest for the Y stop bar.

(2) *Stop bar backstop.* The stop bar backstop (23) is seated in the square hole in the mechanism plate and fastened to the mounting plate by the stop bar backstop mounting screw which also secures the foot retainer. The stop bar backstop limits the travel of the stop bar when it is returned to the Y normal position. The arm of the backstop secures one end of the stop return spring.

(3) *Stop bar return spring.* The stop bar return spring (24) is fastened at one end by the backstop and at the other end by Y stop bar. In the Y normal position, the spring holds the Y stop bar against the backstop, returning it to that position at the end of each step of Y travel.

(4) *Y stop bar.* The Y stop bar (22) is seated on the mechanism plate by the two feet at either end and retained in place by the spring. When the Y magnet assembly operates, the cam moves against the stop bar roller (held in



1 Pawl pin
2 Lock ring (2)
3 Y pawl spring
4 Backstop mounting screw (2, 4–40 x ¼ inch)
5 Y armature backstop
6 Interrupter mounting bolt (2)
7 Interrupter mounting nut (2)
8 Hinge plate
9 Interrupter assembly
10 Interrupter clamp
11 Interrupter bumper and bearing
12 Interrupter bumper nut and washer (2)
13 Interrupter bumper mounting bolt
14 Rectractile spring
15 Hinge plate mounting screw (2, 4–40 x 19/32 inch)
16 Y armature assembly
17 Hinge pin
18 Y magnet coil
19 Y magnet assembly mounting screw (2, 4–40 x ¼ inch)
20 Y magnet frame
21 Y drive pawl
22 Y stop bar
23 Stop bar backstop
24 Stop bar return spring
25 Stop bar backstop mounting screw (4–40 x 5/32 inch)
26 Foot retainer

Figure 15. XY switch, top view (left side).

place by the roller clip) and the stop bar engages the ratchet gear (part of the cog roller assembly) to prevent overthrow during Y stepping.

t. Y Retaining Pawl Assembly (fig. 9). The Y retaining pawl assembly (19) is located to the left of the Y magnet assembly (17) and forward of the cog roller assembly (22). The Y retaining pawl engages the cog roller assembly when the Y armature assembly restores. The Y retaining pawl base (4, fig. 14) mounts the Y retaining pawl (6) and its associated parts. The Y retaining pawl assembly consists of the parts listed below.

(1) *Y retaining pawl assembly base.* The Y retaining pawl base is fastened to the mechanism plate by two Y retaining pawl assembly mounting screws (11). It is a mounting base for the Y retaining pawl and Y ejector bushing. The notched arm anchors one end of the Y retaining pawl spring (9).

(2) *Y retaining pawl.* The Y retaining pawl is fastened to the left side of the base (through the slotted hole) by the Y retaining pawl post, bushing, washer and nut (5, 7, 8, and 10). The pawl maintains the position of the cog roller assembly during Y stepping and is released when the release magnet armature strikes the lower end of the Y retaining pawl.

(3) *Y retaining pawl spring.* The Y retaining pawl spring (9) is located over the Y retaining pawl bushing. It provides the spring tension which operates the Y retaining pawl. One end of the spring is fastened by the notched arm in the base and the other end (bent 90°) fits against the inner surface of the Y retaining pawl.

(4) *Y ejector bushing.* The Y ejector bushing (2) is fastened to the cog roller support by the Y ejector bolt and nut. The Y ejector bushing is a guide for the Y drive pawl.

u. Y Magnet Assembly (fig. 9). The Y magnet assembly (17) is located to the left of center on the mechanism plate (13). When the Y magnet assembly operates, the Y drive pawl engages the serrated teeth of the cog roller assembly (22), driving it one step. With the coil energized, the cam in the neck of the Y armature assembly moves against the stop bar roller (7, fig. 21), thus moving the Y stop bar (22, fig. 15) to a position where it engages the ratchet gear on the cog roller assembly. At the same time, the contact springs of the interrupter assembly (9), riding on the interrupter bumper, are released. When the Y magnet assembly is released, the tension on the retractile spring (14) is relieved, returning the Y armature assembly to its Y normal position against the Y armature backstop. The Y magnet assembly consists of the parts listed below.

(1) *Y magnet frame.* The Y magnet frame (20) is fastened to the mechanism plate by two Y magnet assembly mounting screws (19). It mounts the hinge plate (8), Y magnet coil (18), and Y armature backstop (5).

(2) *Y armature backstop.* The Y armature backstop is fastened to the Y magnet frame by two backstop mounting screws (4). It limits the travel and air gap of the Y armature assembly.

(3) *Y magnet coil.* The Y magnet coil (18) is fastened to the Y magnet frame by the coil mounting screw. When energized, the Y magnet coil attracts the Y armature assembly to the coil core.

(4) *Hinge plate.* The irregularly shaped hinge plate is fastened to the Y magnet frame by the two hinge plate mounting screws (15). The hinge plate mounts the interrupter assembly and clamp (9 and 10). It also fastens one end of the retractile spring, and hinges the Y armature assembly.

(5) *Interrupter assembly.* The interrupter assembly and interrupter clamp are fastened to the hinge plate by two interrupter mounting bolts and nuts (6 and 7). The interrupter assembly is a molded unit, consisting of a metal stop and two contact springs. Normally held in their make (closed) position, the contact springs open each time the Y armature assembly is operated. The two leads to the contact springs are held in place by the interrupter clamp.

(6) *Retractile spring.* The retractile spring (14) is fastened between the hinge plate and Y armature assembly. It maintains the armature (when released) against the Y armature backstop.

(7) *Interrupter bumper.* The adjustable interrupter bumper and bearing (11) is fastened to the arm of the Y armature assembly by means of the interrupter bumper mounting bolt, washer, and nut (12 and 13). It holds the interrupter contact springs closed when the Y armature assembly is in the normal position.

(8) *Y armature assembly.* The Y armature assembly (16) is fastened to the hinge plate (8) by the hinge pin (17) and is held against the Y armature backstop (5) by the action of the retractile spring. The slotted arm of the Y armature assembly mounts the interrupter bumper and the neck of the armature mounts the Y drive pawl (21). When the Y magnet coil is energized, the Y armature assembly is attracted to the coil core and the associated pawl engages the serrated teeth on the cog roller assembly. This same action relieves the pressure of the interrupter bumper from the contact springs of the interrupter assembly.

(9) *Y drive pawl.* The Y drive pawl is fastened through the neck of the Y armature assembly by the pawl pin (1) and two lock rings (2). It engages the serrated teeth of the cog roller when driven in the Y direction.

(10) *Y pawl spring.* The Y pawl spring (3) is fastened between the fixed post in the neck of the Y armature assembly and the mounting hole in the end of the Y drive pawl. The spring maintains the Y drive pawl in the correct position for engagement with the serrated teeth of the cog roller assembly. In the release position, the clip on the Y drive pawl rests against the Y ejector bushing (2, fig. 14).

v. Release Magnet Assembly (fig. 9). The release magnet assembly (18) is located on the left front section of the mechanism plate (13). With the release magnet assembly energized, two of the three hinge bracket extension arms (attached to the release magnet armature assembly) disconnect the Y retaining pawl (6, fig. 14) and X retaining pawl (19). The third extension arm limits the travel of the release magnet armature (2, fig. 10) and air gap. In addition, the narrow neck of the release magnet armature assembly engages the roller of the spring combination (release springs), operating the contact springs to their release position. The release magnet assembly consists of the parts listed below.

(1) *Release magnet frame.* The release magnet frame (15) is fastened to the mechanism plate by two release magnet assembly mounting screws (14). It is a mounting base for the parts of the release magnet assembly.

(2) *Hinge plate.* The hinge plate (13) is fastened to the release magnet frame by two bracket mounting screws (12) and hinges the release magnet armature.

(3) *Release magnet armature assembly.* The release magnet armature is fastened to the hinge plate by the hinge pin (4) and mounts the hinge bracket (11). The narrow neck of the release magnet armature assembly engages the roller of the release springs.

(4) *Release magnet coil.* The release magnet coil (18) is fastened to the release magnet frame by the coil mounting screw (16). When energized, the coil attracts the release magnet armature assembly to its pole piece.

(5) *Hinge bracket.* The irregularly shaped hinge bracket is fastened to the release magnet armature assembly by two hinge bracket screws (3). Two of the three arms serve to disconnect the X and Y retaining pawls and the third arm to limit the travel of the armature assembly and air gap.

(6) *Spring combination (release springs).* The spring combination (19) is fastened to the release magnet frame by two spring combination mounting screws (17). The spring combination is operated by the release magnet armature assembly. The neck of the armature moves against the operating lever of the spring combination, moving the pusher against the contact springs. This action of the spring combination returns the XY switch to its X and Y normal positions. The contact springs, as mounted on the mechanism plate, are numbered from bottom to top, as follows: right row, 1, 3, and 5; and left row, 2 and 4.

w. XX–X Rack Assembly (fig. 9). The XX–X rack assembly (4) is located immediately to the right of the X gear assembly (3). The rack

is stepped in the Y direction by the bell cup gear of the X gear assembly. The spring wiper assemblies (8, fig. 12) perform special switching requirements, and are identified as the X wipers (on the left side of the rack) and the XX wipers (on the right side). The XX–X rack assembly consists of the parts listed below.

(1) *XX–X rack base.* The XX–X rack base (5) is fastened to the mechanism plate by two base mounting screws (6) and mounts the parts of the XX–X rack assembly (but not the XX–X pillar assembly).

(2) *XX–X rack.* The XX–X rack (4) is fastened to the XX–X rack base by two rack way screws (12). The upper arm of the XX–X rack mounts the spring wiper assembly. The upper arm is slotted, providing the means for adjustment of the spring wiper assembly.

(3) *Spring wiper assembly.* The spring wiper assembly (8) spring wiper spacer (10), and cable clamp (13) are fastened to the XX–X rack by the spring wiper nut (11). The cable clamp retains the two conductors from the cable assembly.

(4) *XX–X pillar assembly.* The XX–X pillar assembly (7) is fastened to the mechanism plate by two XX–X pillar mounting screws (9). The XX–X pillar assembly is a rest for the wipers of the spring wiper assembly.

x. Spring Combination Assembly (fig. 10). The spring combination assembly (21) is located in the front left corner of the mechanism plate and fastened by three spring combination assembly mounting screws (20). The three-stack spring pileups consist (from left to right) of the Y off-normal springs, X–Y overflow spring, and the X off-normal spring. The X off-normal spring assembly operates when the switch wipers take the first step in the X direction, the Y off-normal spring assembly operates when the switch wipers move to the first step in the Y direction, and the X–Y overflow spring assembly operates when the wipers move more than 10 steps in either the X or Y direction. The Y off-normal and X–Y overflow cam and toggle lever operate the contact springs of the three-stack spring combination assembly. The contact springs are numbered from bottom to top, right to left as listed below.

(1) X off-normal spring: right row 1, 3, 5, and 7; left row 2, 4, and 6.

(2) X–Y overflow spring: right row 1, 3, 5, and 7; left row 2, 4, and 6.

(3) Y off-normal spring: right row 1, 3, 5, and 7; left row 2, 4, and 6.

y. Guide Rule (fig. 16). The guide rule is located axially on the midsection of the XY switch and fastened to the mechanism plate by the guide rule mounting screw at the left end and the right bearing mounting screw at the right end. The guide rule numbers 1 through 0 stamped on its surface indicate the number of steps the XY switch takes in the X direction.

z. Cable Assembly (fig. 9). The cable assembly is located in the front left corner of the mechanism plate (13) and is terminated by a 36-point switch jack (connector plug) that is used to interconnect the XY switch with its associated circuit plate. With the connector plug faced forward (cable clamp at left), the terminations are identified from left to right, top to bottom, as follows: top row, 1 through 6; second row, 7 through 12; third row, 13 through 18; fourth row, 19 through 24; fifth row, 25 through 30; and bottom row, 31 through 36. The cable assembly consists of the parts listed below.

(1) *Cable.* The cable (fig. 16) is made up of 36 nylon-insulated tinsel color-coded conductors.

(2) *Jack block.* Each cable conductor is soldered to one of the 36 terminations molded into the jack block.

(3) *Housing.* The housing protects the jack block and is secured to it by two plug mounting screws.

(4) *Cable clamp.* The cable clamp secures the block end of the cable to the housing by means of two cable clamp screws.

(5) *Cable clips.* The two cable clips are fastened to the mechanism plate by their respective cable clip screws and hold the cable in place.

64. Operation

The XY switch is a two-motion electro-

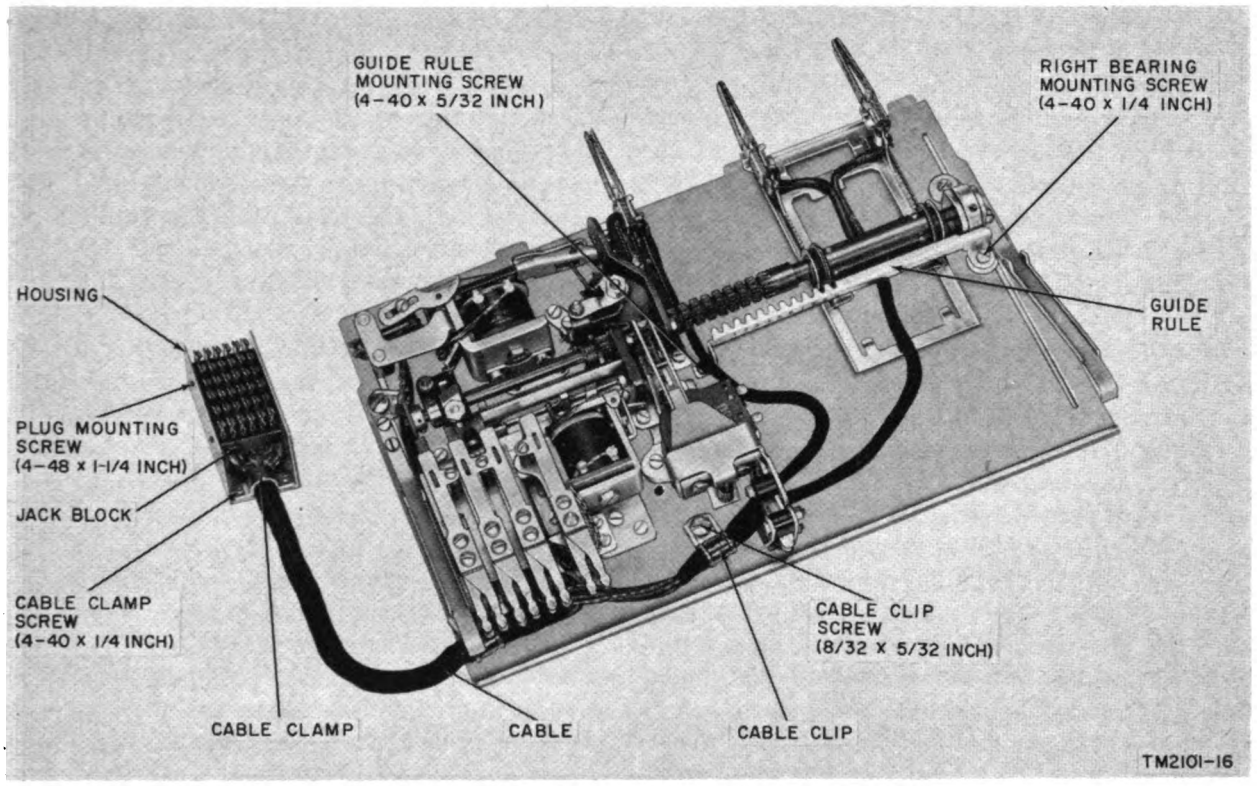


Figure 16. XY switch, front view.

mechanical device that transforms electrical pulses into mechanical motion. The switch is stepped in the X and Y directions and returned to normal by the operation of the electromagnets that are components of the switch. This electromechanical linkage converts electrical power (supplied in the form of pulses to the coils of the magnets) to mechanical motion. The mechanical motion moves the wipers through a possible 10 steps in the X direction and 10 steps in the Y direction, each having one additional step for marking overtravel. This makes possible the selection, by wipers, of any one of 100 connections in the XY banks. The wipers are restored to their at-rest (normal) position when the switch mechanism releases. The mechanical movements necessary for stepping and releasing the switch are described below.

a. X Direction Stepping. The XY switch steps in the X direction when a pulse of current is applied to the winding of the X magnet. When the X magnet winding is energized, the X armature assembly is attracted to the coil core of the X magnet coil; this causes the switch to function as described below.

(1) The drive pawl (attached to the neck of the X armature assembly) engages the teeth of the ratchet gear (part of the X gear assembly), and causes the X gear assembly to turn counterclockwise.

(2) The teeth of the sprocket gear (part of the X gear assembly) engage the annular teeth of the cog roller assembly. This action slides the cog roller assembly and X carriage (the T, R, S, and HS wipers also slide) one step in the X direction.

(3) The teeth of the bell cup gear (part of the X gear assembly) engage the teeth of the XX–X rack assembly. This action slides the XX–X rack one step in the Y direction (moving the X and XX wipers one step in the Y direction).

(4) The switching lever arm is released by the post attached to the X gear assembly (by the first step taken in the X direction), actuating the toggle lever which operates the X off-normal

springs (part of the spring combination assembly).

(5) The X retaining pawl slides over the face of the ratchet gear tooth, engaging the next tooth at the end of the step taken in the X direction. This operation prevents the X gear assembly from returning to normal.

(6) The X return spring is wound tighter, placing it under additional tension. (The winding of eight or nine notches of windup washer during adjustment establishes initial tension.)

(7) The interrupter assembly contact springs break when the X armature operates. This action provides the means for automatic stepping in the X direction. The interrupter contact springs are connected to terminals of the connector plug, providing the connection to the associated equipment (circuit plate). Opening the circuit to the X magnet coil causes the X armature assembly to release. This causes the contact spring of the interrupter assembly to make, completing a circuit to the X magnet coil. For a detailed description of the switching circuits, refer to TM 11–2116.

b. Y Direction Stepping. The XY switch steps in the Y direction when a pulse of current is applied to the winding of the Y magnet. When the Y magnet is energized, the Y armature assembly is attracted to the coil core of the Y magnet coil; this causes the switch to function as described below.

(1) The pawl (attached to the neck of the Y armature assembly) engages the serrated teeth of the cog roller assembly; this causes the cog roller assembly to rotate one step in the Y direction.

(2) The pinion assembly (attached to the sleeve portion of the cog roller assembly) engages the teeth of the Y carriage, driving the Y carriage one step in the Y direction (moving the T, R, S, and HS wipers one step in the Y direction).

(3) The Y off-normal cam releases the lever of the Y off-normal springs (by the first step taken in the Y direction) which operates the spring pileup contacts.

(4) The Y retaining pawl slides over the face of the serrated tooth, engaging the next tooth at the end of each step taken in the Y direction. (In X direction stepping, the Y retaining pawl slides axially along the serrated teeth and remains unengaged.) This operation prevents the cog roller assembly from returning to normal.

(5) The Y return spring is wound tighter, placing it under further torsion. (Rotation into tubular shaft assembly establishes initial torsion.)

(6) The interrupter assembly contact springs break when the Y armature assembly operates. This action provides the means for automatic stepping in the Y direction. The interrupter contact springs are connected to terminals in the connector plug and provides the connection to the associated equipment (circuit plate). Opening the circuit to the Y magnet coil causes the Y armature assembly to release. This last action causes the contact springs of the interrupter assembly to make (close) and thus complete a circuit to the Y magnet coil.

(7) Driven by the cam (an integral part of the Y armature assembly), the Y stop bar limits the rotation during any one step in the Y direction. This limit is achieved by Y stop bar engagement with the ratchet gear (part of the cog roller assembly).

c. Releasing. To release the XY switch, a pulse of current is applied to the winding of the release magnet. The release magnet armature assembly is attracted to the coil core, causing the switch to function as described below.

(1) The hinge bracket extension arms (attached to the release magnet armature) disconnects the Y retaining pawl from the cog roller assembly and the X retaining pawl from the X gear assembly. This action causes the operations described in (*a*) and (*b*) below.

(*a*) The Y return spring is released, rotating the cog roller assembly and

the pinion assembly (wipers T, R, S, and HS) to the Y normal position against the Y stop.

(*b*) The X return spring is released, rotating the X gear assembly clockwise. This action slides the cog roller assembly and pinion assembly to the X normal position against the bearing support. During the same action, the XX–X rack assembly is engaged by the X gear assembly (wiper XX and X) and returned to the X normal position. The X gear assembly also engages the switching lever and rotates the toggle lever on the spring combination assembly, thus returning the X off-normal springs to their X normal condition.

(2) The neck of the release magnet armature assembly engages the lever of the release springs. Contacts 4–5 make (close) and complete an external circuit from ground. When contacts 3–4 of the X off-normal springs break (open), the circuit to the release magnet assembly is opened. This action restores the release magnet assembly to the normal condition, releasing contacts 4–5 of the release springs and removing the ground from the circuit.

d. Overflow. The designation *overflow* indicates the position of the wipers when the XY switch takes 11 steps in the X or Y direction. This causes the XY switch to function as described below.

(1) When 11 steps are taken in the X direction, the post attached to the X gear assembly engages the right-angle arm of the switching lever and moves it to the extreme right position. This action rotates the toggle lever to the left, operating the lever of the X–Y overflow springs.

(2) When 11 steps are taken in the Y direction, the X–Y overflow cam (secured to the tubular shaft assembly) operates the lever of the X–Y overflow springs.

Section III. DISASSEMBLY OF XY SWITCH

65. Disassembly

The disassembly instructions for mechanical assemblies and parts are presented in step-by-step order. Familiarity with these procedures will enable the repairman to replace a particular part or assembly without following the order of disassembly described in this manual. For example, to remove the X magnet coil on the X magnet assembly, unsolder the leads; move the cog roller assembly to the X–11 position; use the end wrench to remove the coil mounting screw, and thus free the X magnet coil. There is no need to remove any other part to accomplish this disassembly. To remove an assembly, the order of disassembly should be studied. Sometimes only partial disassembly is required for removal of the assembly desired. For example, to disassemble the X gear assembly, the ejector strap (part of the X retaining pawl assembly) must first be removed. No other part of the X retaining pawl assembly need be disassembled before proceeding with removal of the X gear assembly.

66. Disassembly of X Magnet, X Retaining Pawl, X Gear and XX–X Rack Assemblies (fig. 17)

a. X Magnet Assembly.

(1) Tag and unsolder the leads connected to the X magnet coil and interrupter assembly contacts.

(2) Remove the armature backstop (2) by removing the two armature backstop mounting screws (1).

(3) Operate the cog roller assembly to the X–11 position.

(4) Remove the X magnet assembly by removing the two X magnet assembly mounting screws (3).

(5) Return the cog roller assembly to its normal position.

(6) Remove the X magnet frame (6) by removing the two bracket mounting screws (4) from the X magnet mounting bracket (5).

(7) Use an end wrench to remove the X magnet coil (8).

(8) Remove the coil mounting screw (7).
(9) Remove the hinge bracket (10) by removing the two hinge bracket mounting screws (9) from the X magnet frame.
(10) Use long-nosed pliers to remove the retractile spring (11) from the arm of the hinge bracket and X armature assembly.
(11) Remove the interrupter clamp (14) and interrupter assembly (15) by removing the two interrupter assembly mounting bolts (12) and two interruptor mounting nuts (13).
(12) Lift out the X armature hinge pin (16) to release the X armature assembly (17).
(13) Remove the interrupter bumper bearing (20) and interrupter bumper (21) by removing the interrupter mounting bolt, nut, and two washers, (19, 18, and 22).
(14) Remove the X drive pawl (23) from the neck of the X armature assembly by removing the two lock rings (24) that fasten the X drive pawl pin (25).
(15) Use long-nosed pliers to remove the X drive pawl spring (26) from inner neck of X armature assembly.

b. X Retaining Pawl Assembly.

(1) Hold the X retaining pawl post (37) (through hole in underside of mechanism plate) with a slit screwdriver and remove the X retaining pawl post nut (27).
(2) Remove the ejector strap (28) by removing the X gear post nut (38).
(3) Remove the X retaining pawl (30), X retaining pawl spring (31), bushing (32), and three washers (29 and 33) from the X retaining pawl post.
(4) Remove the X retaining pawl assembly base (35) by removing the two X retaining pawl assembly base screws (34) and remove the lockwasher (36) and X retaining pawl post (37).

c. X Gear Assembly.

(1) Remove the X gear post nut (38) and slide the X gear post (39) out of the bottom of the mechanism plate.
(2) Remove the two cog roller support screws (16, fig. 20) and rotate cog roller support (17) out of the way.
(3) Detach one end of the X return spring (43, fig. 17) and remove the X gear cluster (40), X ratchet bushing (lower) (41) and X ratchet bushing (upper) (42).
(4) Detach the other end of the X return spring from the windup washer (44).
(5) Remove the windup washer locking screw (45).

d. XX–X Rack Assembly.

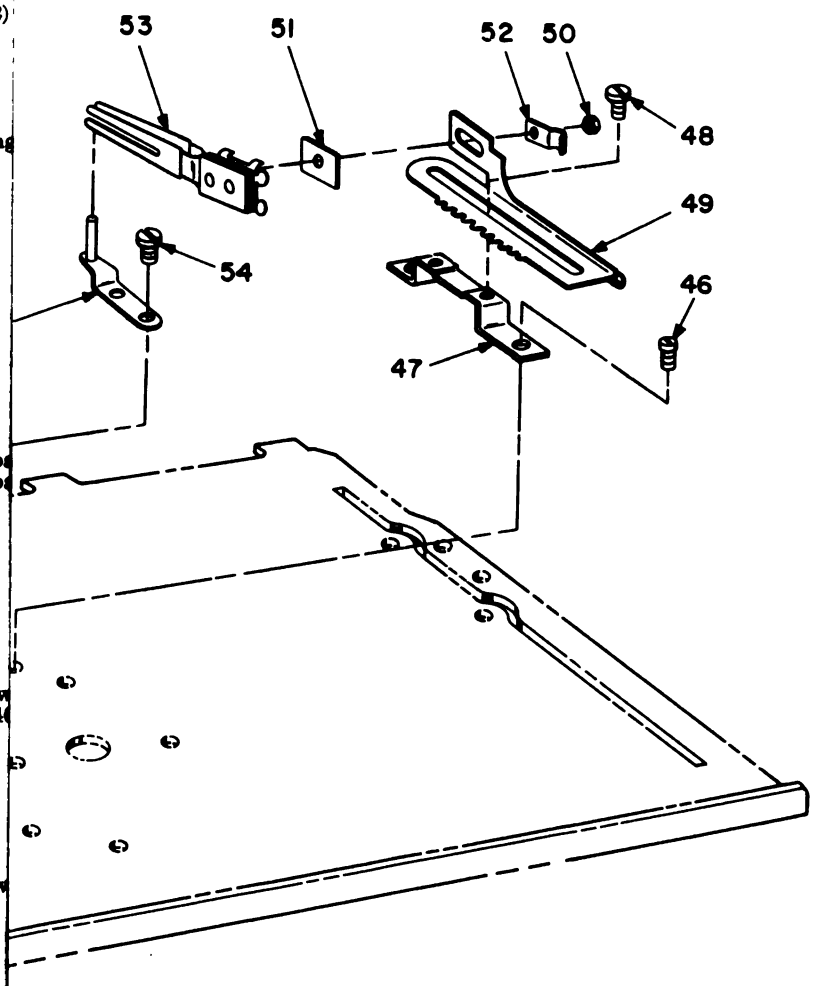
(1) Tag and unsolder the leads connected to the spring wiper assembly.
(2) Remove the XX–X rack base (47) by removing the two base mounting screws. (46).
(3) Remove the XX–X rack (49) by removing the two rack way screws (48) from the XX–X rack base.
(4) Remove the spring wiper assembly (53) and cable clamp (52) by removing the spring wiper nut and spacer (50 and 51) from the XX–X rack.
(5) Remove the XX–X pillar assembly (55) by removing the two XX–X pillar mounting screws (54) from the mechanism plate.

67. Disassembly of Y Magnet Assembly and Y Retaining Pawl Assembly
(fig. 18)

a. Y Magnet Assembly.

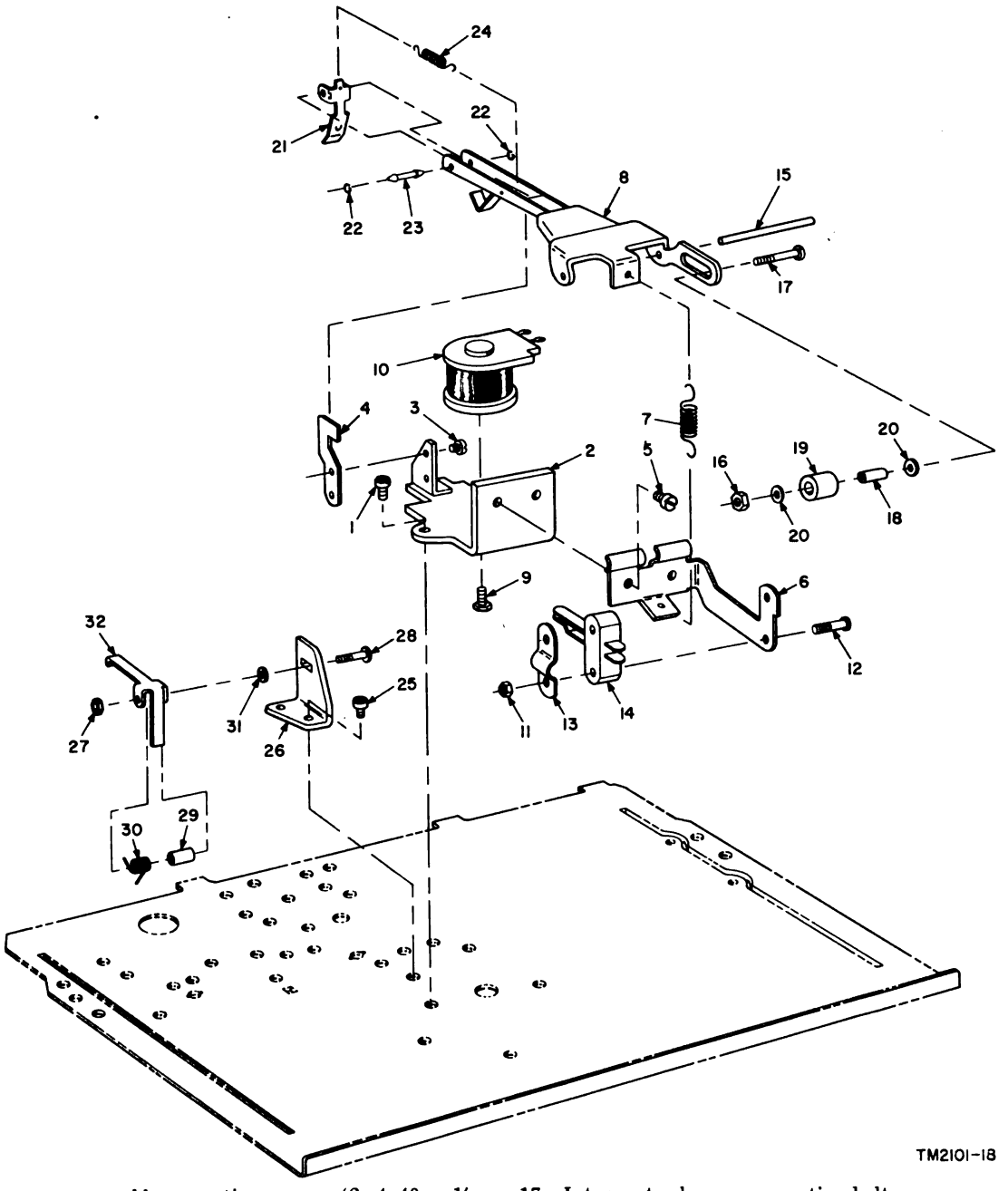
(1) Tag and unsolder the leads connected to the Y magnet coil.
(2) Remove the Y magnet assembly by removing the two Y magnet assembly mounting screws (1) from the Y magnet frame (2).
(3) Remove the Y armature backstop (4) by removing the two backstop mounting screws (3).
(4) Remove the hinge plate (6) by removing the two hinge plate mounting screws (5) from the Y magnet frame.
(5) Use long-nosed pliers to remove the retractile spring (7) from the Y armature assembly (8).

1 Armature backstop mounting
2 Armature backstop
3 X magnet assembly mountin
4 Bracket mounting screw (2, 8
5 X magnet mounting bracket
6 X magnet frame
7 Coil mounting screw (Hex 8-
8 X magnet coil
9 Hinge bracket mounting scre
10 Hinge bracket
11 Retractile spring
12 Interrupter assembly mountir
13 Interrupter mounting nut (2)
14 Interrupter clamp
15 Interrupter assembly
16 X armature hinge pin
17 X armature assembly
18 Interrupter bumper nut
19 Interrupter bumper mountin
20 Interrupter bumper bearing
21 Interrupter bumper
22 Washer (2)
23 X drive pawl
24 Lock ring (2)
25 X drive pawl pin
26 X drive pawl spring
27 X retaining pawl post nut
28 Ejector strap
29 Washer (2)
30 X retaining pawl
31 X retaining pawl spring
32 Bushing
33 Washer
34 X retaining pawl assembly b
35 X retaining pawl assembly b
36 Lock washer
37 X retaining pawl post
38 X gear post nut
39 X gear post
40 X gear cluster
41 X ratchet bushing (lower)
42 X ratchet bushing (upper)
43 X return spring
44 Windup washer
45 Windup washer locking screw
46 Base mounting screw (2, 4-4
47 XX-X rack base
48 Rack way screw (2)
49 XX-X rack
50 Spring wiper nut
51 Spring wiper spacer
52 Cable clamp
53 Spring wiper assembly
54 XX-X pillar mounting screw
55 XX-X pillar assembly



TM2101-17

, exploded view.



1 Y magnet assembly mounting screw (2, 4–40 x ¼ inch)
2 Y magnet frame
3 Backstop mounting screw (2, 4–40 x ¼ inch)
4 Y armature backstop
5 Hinge plate mounting screw (2, 4–40 x 3/16 inch)
6 Hinge plate
7 Retractile spring
8 Y armature assembly
9 Coil mounting screw (hex 8–36 x ¼ inch)
10 Y magnet coil
11 Interrupter mounting nut (2)
12 Interrupter mounting bolt (2)
13 Interrupter clamp
14 Interrupter assembly
15 Y magnet hinge pin
16 Interrupter bumper nut
17 Interrupter bumper mounting bolt
18 Interrupter bumper bearing
19 Interrupter bumper
20 Interrupter bumper washer (2)
21 Y drive pawl
22 Lock ring (2)
23 Y magnet pawl pin
24 Y magnet pawl spring
25 Y retaining pawl assembly mounting screw (2, 4–40 x 3/32 inch)
26 Y retaining pawl base
27 Y retaining pawl nut
28 Y retaining pawl post
29 Y retaining pawl bushing
30 Y retaining pawl spring
31 Y retaining pawl washer
32 Y retaining pawl

Figure 18. Y magnet and Y retaining pawl assemblies, exploded view.

(6) Use an end wrench to remove the coil mounting screw (9) from the Y magnet coil (10).

(7) Remove the two interrupter mounting nuts and bolts (11 and 12) and remove the interrupter clamp (13) and interrupter assembly (14).

(8) Lift out the Y magnet hinge pin (15) on the Y armature assembly.

(9) Remove the interrupter bumper (19), interrupter bumper bearing (18) and the two interrupter bumper washers (20) by removing the interrupter bumper nut and mounting bolt (16 and 17).

(10) Remove the Y driving pawl (21) from the neck of the Y armature assembly by removing the two lock rings (22).

(11) Use long-nosed pliers to remove the Y magnet pawl pin (23).

(12) Remove the Y magnet pawl spring (24).

b. Y Retaining Pawl Assembly.

(1) Remove the Y retaining pawl assembly by removing the two Y retaining pawl assembly mounting screws (25) from the Y retaining pawl base (26).

(2) Remove the Y retaining pawl bushing (29), spring (30), washer (31), and retaining pawl (32) by removing the Y retaining pawl nut and post (27 and 28).

68. Disassembly of Release Magnet Assembly, Spring Combination (Release Springs) and Spring Combination Assembly (fig. 19)

a. Release Magnet Assembly and Spring Combination (Release Springs).

(1) Tag and unsolder the leads connected to the release magnet assembly.

(2) Remove the release magnet assembly by removing the two release magnet assembly mounting screws (1) from the release magnet frame (2).

(3) Remove the hinge plate (4) and release the magnet armature assembly (5) by removing the two bracket mounting screws (3); this will free the release magnet armature assembly.

(4) Use an end wrench to remove the release magnet coil (7) by removing the coil mounting screw (6).

(5) Lift out the release magnet hinge pin (8) on the release magnet armature assembly.

(6) Remove the hinge bracket (10) by removing the two hinge bracket screws (9) from the release magnet armature assembly.

(7) Remove the spring combination (12) by removing the two spring combination mounting screws (11).

b. Spring Combination Assembly (Y Off-Normal Springs, X–Y Overflow Springs, and X Off-Normal Springs.)

(1) Tag and unsolder the leads connected to the spring combination assembly contact springs.

(2) Remove the spring combination assembly (14) by removing the three spring combination assembly mounting screws (13).

69. Disassembly of Tubular Shaft, Cog Roller, Carriage and Spring Wiper Assembly (fig. 20)

a. Tubular Shaft and Cog Roller Assemblies.

(1) Remove the Y return spring lock screw (1).

(2) Slide the Y return spring assembly (2) out of the right end of the tubular shaft (6).

(3) Use an Allen wrench to loosen the two digit drum setscrews (3).

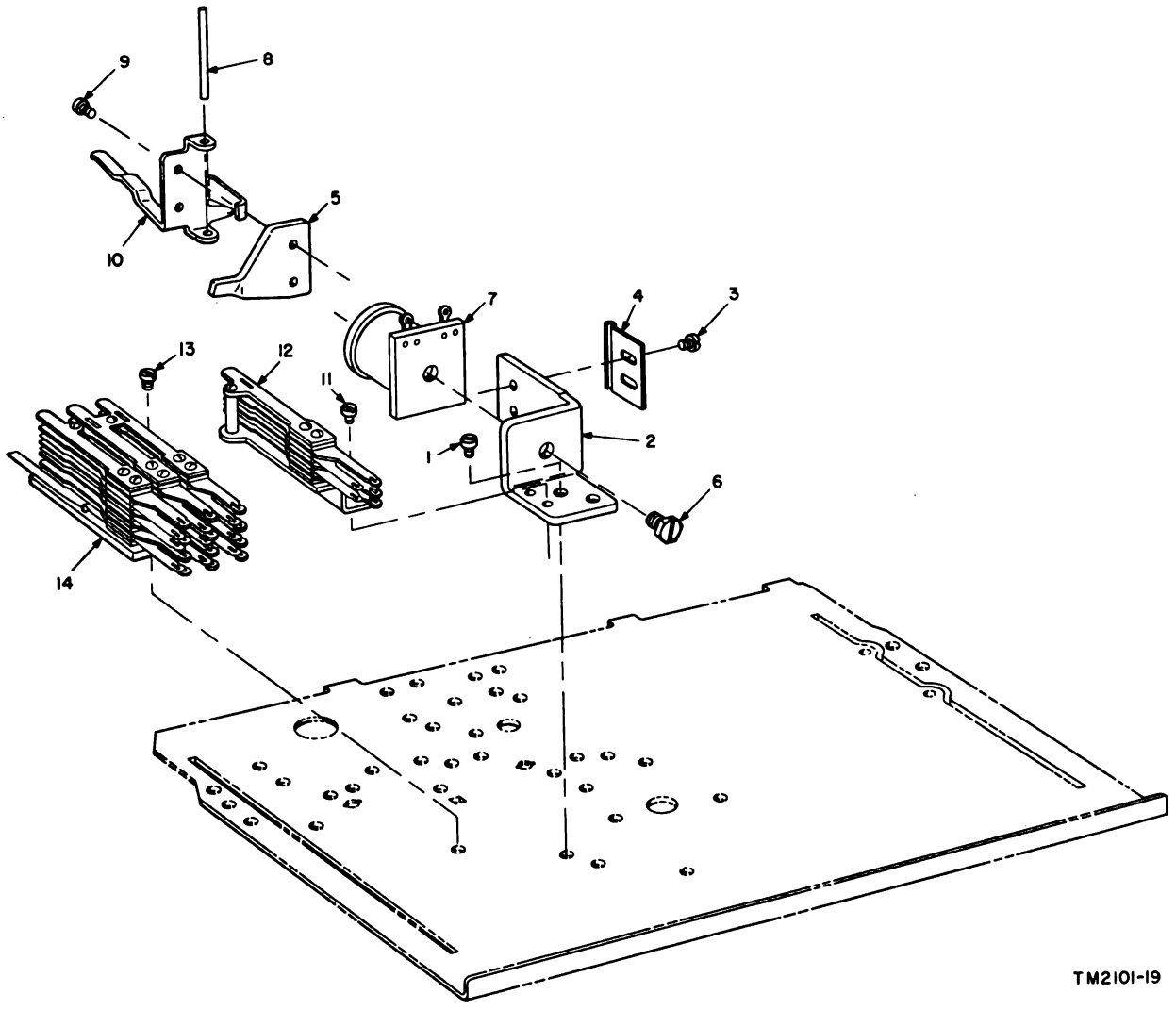
(4) Slide the tubular shaft (6) to the left out of the right yoke (25) as far as possible. (Do not force.) Remove the digit drum (7) from the right yoke (25).

(5) Slide the cog roller assembly (8) to the 0 position on the guide rule (30).

(6) Rotate the cog roller assembly until the Truarc retaining ring (4) on the left end of the cog roller assembly (8) is accessible with the Truarc pliers.

(7) Use the Truarc pliers to remove the Truarc retaining ring (4) from the left end of the cog roller (8).

(8) Slide the tubular shaft (6) to the left through the bearing support with the



1 Release magnet assembly mounting screw (2, 4–40 x 7/32 inch)
2 Release magnet frame
3 Bracket mounting screw (2, 4–48 x 5/32 inch)
4 Hinge plate
5 Release magnet armature
6 Coil mounting screw (hex 8–36 x ¼ inch)
7 Release magnet coil
8 Release magnet hinge pin
9 Hinge bracket screw (2, 4–48 x 5/32 inch)
10 Hinge bracket
11 Spring combination mounting screw (2, 4–48 x 5/32 inch)
12 Spring combination
13 Spring combination assembly mounting screw (2, 4–40 x ¼ inch)
14 Spring combination assembly

Figure 19. Release magnet and spring combination assemblies, exploded view.

left hand and hold the three cog roller keys (5) out of the slot on the tubular shaft with the fingers of the right hand.

(9) Use an Allen wrench to loosen the two cam set screws (11) in the Y off-normal cam (9) and the X–Y overflow cam (10) and slide the two cams off the tubular shaft.

(10) Use an Allen wrench to loosen the stop collar setscrew (12) in the stop collar (13) and slide the stop collar to the right off the tubular shaft.

(11) Carefully tap the T portion of the Y stop (14) until it disengages from the plug key (15) and remove both parts from the tubular shaft.

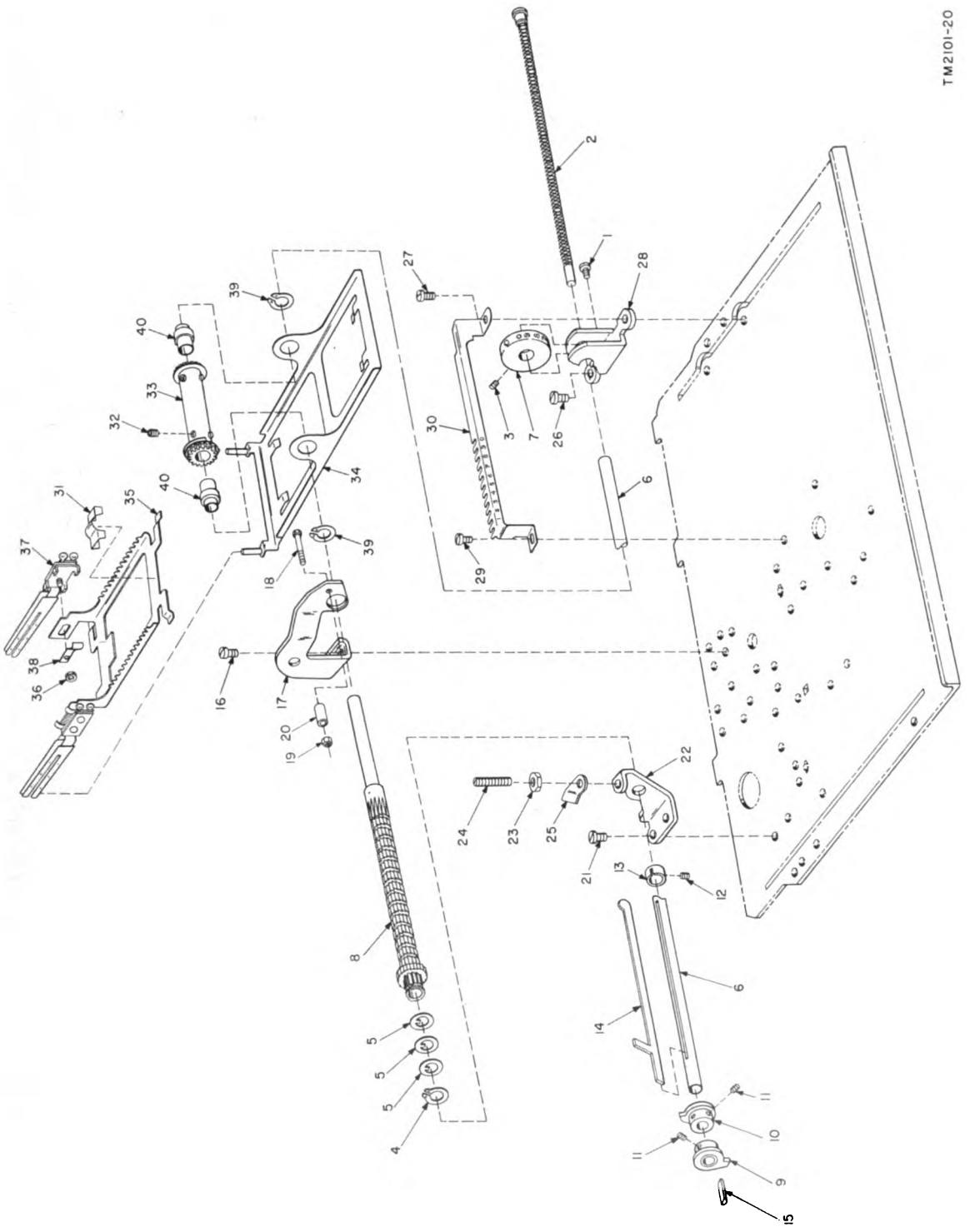


Figure 20. Tubular shaft, cog roller, carriage and spring wiper assemblies, exploded view.

1 Y return spring lock screw (6–40 x 5/32 inch)
2 Y return spring assembly
3 Digit drum set screw (2, 6–40 x 1/8 inch)
4 Truarc retaining ring
5 Cog roller key (3)
6 Tubular shaft
7 Digit drum
8 Cog roller
9 Y off-normal cam
10 X–Y overflow cam
11 Cam set screw (4, 6–40 x 1/8 inch)
12 Stop collar set screw (6–40 x 1/8 inch)
13 Stop collar
14 Y stop
15 Plug key
16 Cog roller support screw (2, 4–40 x 5/32 inch)
17 Cog roller support
18 Y ejector bolt
19 Y ejector nut
20 Y ejector bushing
21 Bearing support mounting screw (2, 6–40 x 3/16 inch)
22 Bearing support
23 Lock nut
24 Y stop screw (6–40 x 1 1/8 inch)
25 Y limit cam
26 Right yoke mounting screw (rear) (4–40 x 1/4 inch)
27 Right yoke mounting screw (front) (4–40 x 1/4 inch)
28 Right yoke
29 Guide rule mounting screw (4–40 x 5/32 inch)
30 Guide rule
31 Cable clip
32 Pinion set screw (4, 6–40 x 1/8 inch)
33 Pinion assembly
34 X carriage assembly
35 Y carriage
36 Spring wiper nut (2)
37 Spring wiper assembly (2)
38 Cable clamp (2)
39 Truarc bearing retaining ring (2)
40 Bearing (2)

Figure 20—Continued.

(12) Remove the bearing support (22) by removing the two bearing support mounting screws (21).

(13) Use a split screwdriver to hold the Y stop screw (24) in place and loosen the locknut (23) and remove the Y stop screw, the locknut and the Y limit cam (25).

(14) Use an Allen wrench to loosen the six pinion assembly setscrews (32) on the pinion assembly (33).

(15) Remove the cog roller support (17) by removing the two cog roller support screws (16).

(16) Slide the sleeve end of the cog roller assembly and the cog roller support out of the pinion assembly.

(17) Remove the pinion assembly from the X wiper assembly.

(18) Slide the cog roller support (17) off the cog roller assembly.

(19) Remove the Y ejector bushing (20) by removing the Y ejector bolt (18) and nut (19) from the cog roller support.

Caution: **Do not remove the right yoke unless *absolutely* required.**

(20) Remove the right yoke (28) by removing the right bearing mounting screw (rear) (26) and right bearing mounting screw (front) (27).

Note. The front bearing mounting screw also secures one end of the guide rule.

(21) Remove the guide rule mounting screw (29) and remove the guide rule (30).

b. Carriage, Pinion, and Spring Wiper Assemblies.

(1) Tag and unsolder leads connected to the wiper assembly contacts.

(2) Unfasten cable clip (31).

(3) Lift the Y carriage (35) free of the X carriage assembly (34).

(4) Remove two spring wiper assemblies and cable clamps (38) by removing the two spring wiper nuts (36).

(5) Use the Truarc pliers to remove the two Truarc bearing retaining plugs (39).

(6) Remove the bearing (40) from the X carriage assembly.

70. Disassembly of Y Stop Bar Assembly, Cable Assembly, Switching Lever and Lockspring (fig. 21)

a. Y Stop Bar Assembly.

(1) Remove the stop bar backstop (2) and foot retainer (3) by removing the stop bar backstop mounting screw (1).

(2) Use long-nosed pliers to remove the stop bar return spring (4) and lift the Y stop bar (5) from the retaining holes in the mechanism plate (20).

(3) Use long-nosed pliers to remove the roller clip (6) that fastens the stop bar roller (7) to the Y stop bar.

b. Cable Assembly.

(1) Remove the two cable clips (8) on the mechanism plate by removing the two cable clip screws (9).

(2) Remove the cable clamp (11) on the connector plug by removing the two cable clamp screws (10).

(3) Remove the jack block (13) on the connector plug by removing the two plug mounting screws (12).

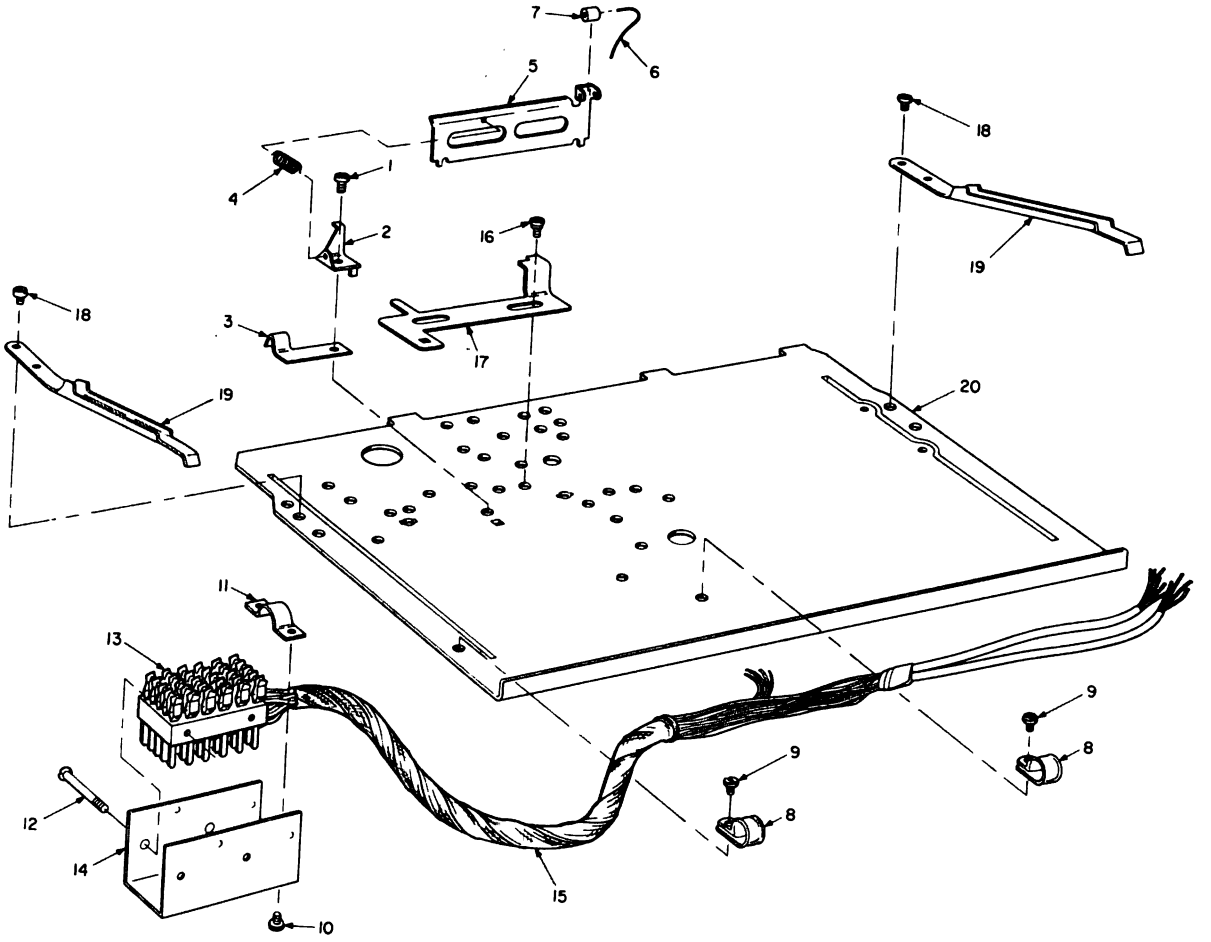
(4) Remove the housing (14).

(5) Tag and unsolder the leads from the jack block and remove the cable (15).

c. Switching Lever and Lockspring.

(1) Remove the switching lever (17) by removing the two way screws (16) from the mechanism plate.

(2) Remove the two lockspring mounting screws (18) from each of the two locksprings (19).



TM2101-21

1 Stop bar backstop mounting screw (4–40 x $\frac{5}{32}$ inch)
2 Stop bar backstop
3 Foot retainer
4 Stop bar return spring
5 Y stop bar
6 Roller clip
7 Stop bar roller
8 Cable clip (2)
9 Cable clip screw (2, 8–32 x $\frac{3}{32}$ inch)
10 Cable clamp screw (2, 4–40 x ¼ inch)
11 Cable clamp
12 Plug mounting screw (2, 4–48 x 1¼ inch)
13 Jack block
14 Housing
15 Cable
16 Way screw (2)
17 Switching lever
18 Lockspring mounting screw (4, 4–40 x $\frac{3}{32}$ inch)
19 Lockspring (2)
20 Mechanism plate

Figure 21. Switching lever, Y stop bar and cable assemblies, exploded view.

Section IV. REASSEMBLY OF XY SWITCH

71. Reassembly

The reassembly instructions for the XY switch presented in step-by-step order provide for rough adjustment of all parts and assemblies. Specific adjustment instructions are listed in paragraph 77 through 94.

Caution: **Do not attempt to operate the XY switch until final adjustments and testing are completed.**

72. Reassembly of Lockspring, Bearing Support, Right Yoke, Guide Rule, and Switching Lever

a. Lockspring (fig. 21).

(1) Position one of the two interchangeable locksprings (19) over the mounting holes on the right end of the mechanism plate (20) and fasten with the two lockspring mounting screws (18).

(2) Repeat the procedure for the left end.

b. Right Yoke, Bearing Support, and Guide Rule (fig. 20).

(1) Replace the right yoke (28) on the mechanism plate with the single hole facing the left side.

(2) Fasten the rear of the yoke to the mechanism plate with the right bearing mounting screw (rear) (26).

(3) Position the right end of the guide rule (30) over the front hole (numbers facing forward) and fasten the yoke and rule to the mechanism plate with the right bearing mounting screw (front) (27).

(4) Fasten the left end of the guide rule with the guide rule mounting screw (29).

(5) Fasten the bearing support (22) to the mechanism plate with the two bearing support mounting screws (21).

(6) Fasten the Y stop screw (24) into the upper arm of the bearing support, leaving approximately three-sixteenths of an inch extending above the face of the arm.

(7) Slide the Y limit cam (25) over the screw, facing it at right angles to the front of the mechanism plate and fasten it with the locknut (23).

c. Switching Lever (fig. 21).

(1) Position the switching lever (17) over the mounting holes, with the elevated arm at the right.

(2) Fasten the switching lever to the mechanism plate (20) with the two way screws (16), tightening the screws until the collar portion is flush with the plate. In this position, the switching lever is free to slide left or right.

73. Reassembly of Tubular Shaft, Carriage, Pinion, and Spring Wiper Assemblies (fig. 20)

a. Tubular Shaft Assembly.

(1) Insert the Y stop (14) into the keyway in the tubular shaft (6).

(2) Slide the Y stop to the left end of the keyway.

(3) Slip the stop collar (13) over the right end of the tubular shaft and slide the left end until the slot in the collar seats the arm of the Y stop.

(4) Insert the plug key (15) in the left-end bottom opening of the tubular shaft, leaving approximately one-third to one-quarter of its length extending past the end of the shaft.

(5) Reseat the stop collar and secure with the stop collar setscrew (12).

(6) Carefully tap the plug key flush with the left end of the shaft.

b. X and Y Carriage and Spring Wiper Assemblies.

(1) Replace the two bearings (40) into the X carriage assembly (34) and fasten with the two Truarc bearing retaining rings (39).

(2) Mount the spring wiper assembly (37) to the arm of the Y carriage (35) and slide the cable clamp (38) over the screw. Fasten the assembly by tightening the spring wiper nut (36) with the end wrench.

(3) Repeat the procedure in (2) above for reassembly of the second spring wiper assembly to the other arm of the Y carriage.

(4) Replace the Y carriage into the X carriage assembly (34) with the tips of the wipers resting on the pillars of the X wiper assembly and the feet of the Y carriage one-sixteenth of an inch forward from the rear of the X carriage assembly.

(5) Insert the pinion assembly (33) between the bearing surfaces of the X carriage assembly. The notched flange of the pinion assembly should be on the left side of the carriage. With the teeth of the pinion assembly engaging the teeth of the X carriage.

c. Cog Roller, Cog Roller Support, Digit Drum, and Tubular Shaft.

(1) Insert the Y ejector bolt (18) through the Y ejector bushing (20) and the cog roller support (17) and fasten with the Y ejector nut (19).

(2) Insert the sleeve end of the cog roller (8) through the cog roller support.

(3) Insert the sleeve end of the cog roller through the X carriage assembly (34) and the pinion assembly (33).

(4) Insert the right end of the tubular shaft (6) one-fourth of the way through the bearing support (22) with the slot of the tubular shaft facing upward.

(5) Replace the Truarc retaining ring (4) and then the three cog roller keys (5) on the right end of the tubular shaft.

(6) Position the cog roller support (which is attached to the cog roller) on the mechanism plate. The pinion assembly should be positioned on the mechanism plate parallel to the guide rule. See that the notched flange on the pinion assembly is positioned properly in respect to the guide rule; it should clear the guide rule by .40 of an inch and should slide with no bind or drag on the sleeve end of the cog roller.

(7) Insert the tubular shaft partially through the cog roller with the left hand, and position the three cog roller keys into the slot of the tubular shaft.

(8) Aline the slot on the left end of the cog roller with the slot on the tubular shaft.

(9) Slide the three cog roller keys in the slot of the tubular shaft ((7) above) into the slot on the left end of the cog roller and fasten the Truarc retaining ring.

(10) Insert the digit drum (7) into the right yoke (28) and slide the tubular shaft through the cog roller right yoke, and digit drum.

(11) Slide the left end of the cog roller flush against the bearing support.

(12) Slide the pinion assembly and X and Y carriage assembly on the sleeve of the cog roller until the left side of the X carriage assembly is even with the left end of the guide rule.

(13) Rotate the pinion assembly. The Y carriage should move freely in the Y direction and the notched flange on the pinion should be centered in the first notch (left end) of the guide rule.

(14) Return the pinion assembly to its normal position.

(15) Check the position of the Y carriage again (*b*(4) above).

(16) Tighten the six pinion setscrews (32) on the pinion assembly.

(17) Slide the cog roller back and forth over the tubular shaft. It should bind only slightly since the cog roller support is not fastened. If it binds excessively, either the right yoke or bearing support mounting screws must be loosened and the part repositioned.

(18) Fasten the cog roller support (17) to the mechanism plate with the two cog roller support screws (16). The cog roller should not bind, but should have a slight drag. If it binds, the cog roller support screws should be loosened and repositioned.

(19) Insert the Y return spring assembly (2) into the right end of the tubular shaft assembly and turn it slowly until there is a slight click to indicate its engagement within the tubular shaft.

(20) Install the Y return spring lock screw into the right yoke.

(21) Wind the Y return spring clockwise 9 complete turns and tighten the Y re-

turn spring lock screw until it engages the indentation in the screw head.

(22) Place the X–Y overflow cam (10) on the left end (faced right) of the tubular shaft, approximately five-eighths of an inch from the end of the shaft.

(23) Rotate the tubular shaft assembly until the Y stop engages the Y limit cam.

(24) Rotate the X–Y overflow cam until the notched surface is parallel to the mechanism plate. Tighten the two cam set screws (11) and return the tubular shaft assembly to the normal position.

(25) Place the Y off-normal cam (9) on the left end (faced left) of the tubular shaft assembly, approximately three-thirty-seconds of an inch from the X–Y overflow cam.

(26) With the tubular shaft in the normal position, rotate the Y off-normal cam until the notched tooth is parallel to the mechanism plate. Tighten the two cam setscrews (11).

(27) Position the digit drum (7) until the bottom portion of the digit drum setscrew hole under the digit one is parallel to the guide rule (30).

(28) Tighten the two digit drum setscrews (3).

Note. The pinion assembly automatically positions the Y carriage in relation to the X carriage assembly with regard to side play.

74. Reassembly of X Retaining Pawl, X Gear, X Magnet, and XX–X Rack Assemblies (fig. 17)

a. X Retaining Pawl Assembly.

(1) Slide the X retaining pawl post (37) through the lockwasher (36) (when used) and through the forward hole in the X retaining pawl assembly base (35).

(2) Position the X retaining pawl assembly base with X retaining pawl post on the mechanism plate and fasten with the two X retaining pawl assembly base screws (34).

Note. The lockwasher (36) is not always used. On most XY switches, the screw head of the X retaining pawl post (37) has serrated teeth and the lower edge of the hole in the X retaining pawl assembly base is also serrated.

(3) Slide the X retaining pawl spring (31) on the bushing (32) and position the bushing between the holes in the X retaining pawl (30).

(4) Slide the X retaining pawl spring, and bushing on the X retaining pawl post, separating them with the washers (33) supplied. Be certain to position the assembled parts so that the X retaining pawl and arm of the base engage the two ends of the spring.

(5) Slide the straight end of the ejector strap (28) and two washers (29) on the post and fasten with the X retaining pawl post nut (27).

b. X Gear Assembly.

(1) Place the windup washer (44) over the X gear post hole.

(2) Position the X ratchet bushing (lower) (41) into the windup washer.

(3) Insert the X return spring (43) into the X gear cluster (40). The projection on the upper half of the X return spring must fit into the hole in the upper half of the X gear cluster.

(4) Insert the X ratchet bushing (upper) (42) into the X gear cluster.

(5) Position the X gear cluster (40), X return spring (43), and X ratchet bushing (upper) over the windup washer.

(6) Insert the X gear post (39) up through the hole in the mechanism plate and through the X gear cluster.

(7) Loosen the X retaining pawl post nut (27) so that the other end of the ejector strap (28) may be slipped over the X gear post (properly seated down over face of the ratchet gear). Retighten the X retaining pawl post nut.

(8) Position the X gear cluster so that a center line drawn through the index hole (in the sprocket gear), X gear post, and sprocket tooth (mating with annular teeth of cog roller) is at right angles to a center line drawn through the cog roller when sighted by eye.

(9) Tighten the X gear post nut suffici-

ently to hold the X gear cluster in approximately the right position ((8) above). Be sure that the protruding post (below the sprocket gear) engages the switching lever in the normal and X–11 positions.

(10) Use two screwdrivers (one to wind the windup washer (12 notches) and the other to hold it in place until the windup washer locking screw (45) is fastened.

c. X Magnet Assembly.

(1) Fasten the armature backstop (2) to the mechanism plate with the two armature backstop mounting screws (1).

(2) Insert the X drive pawl (23) in the neck of the X armature assembly (17) and fasten in place with the X drive pawl pin (25) and two lock rings (24).

(3) Insert the interrupter bumper mounting bolt (19) in the slotted arm of the X armature assembly.

(4) Slide the washer (22) interrupter bumper bearing (20), interrupter bumper (21), and second washer (22) over the interrupter bumper bolt, position the bumper in the center of the mounting slot on the X armature. Fasten it with the interrupter bumper mounting nut (18).

(5) Insert the X armature hinge pin (16) through the holes in the X armature assembly (17).

(6) Center the X armature assembly so that the X armature hinge pin fits into the bracket (10). Fasten the hinge bracket to the X magnet frame (6) with the two hinge bracket mounting screws (9). Check to see that the armature moves freely of its own weight.

(7) Insert the two interrupter assembly mounting bolts (12) through the mounting holes on the hinge bracket.

(8) Slide the interrupter assembly (15) and interrupter clamp (14) over the bolts and fasten them to the arm of the hinge bracket with the two interrupter mounting nuts (13).

(9) Use the end wrench to fasten the X magnet coil (8) to the X magnet frame with the coil mounting screw (7).

(10) Fasten the X magnet mounting bracket (5) to the X magnet frame with the two bracket mounting screws (4).

(11) Use long-nosed pliers to replace the retractile spring (11) between the holes of the X armature and hinge bracket.

(12) Position the X magnet assembly over the holes in the mechanism plate and fasten it with the two magnet assembly mounting screws (3).

(13) Position the X magnet assembly approximately in its correct position to determine if the assembled parts function.

d. XX–X Rack Assembly.

(1) Move the cog roller to the X overflow position (X–11 position).

(2) Fasten the XX–X rack base (47) to the mechanism plate with the two base mounting screws (46).

(3) Position the XX–X rack (49) so that the last tooth engages the bell cup gear teeth on the X gear cluster (40).

(4) Fasten the XX–X rack to the XX–X rack base with the two rack way screws (48).

(5) Release the switch (returning it to the normal position) and check to see that the rear teeth of the XX–X rack mesh with the bell cup gear teeth on the X gear cluster.

(6) Replace the spring wiper spacer (51) on the spring wiper assembly (53).

(7) Insert the spring wiper assembly through the arm of the XX–X rack from the left side.

(8) Replace the cable clamp (52) and fasten the spring wiper spacer and the cable clamp with the spring wiper nut (50).

(9) Fasten the XX–X pillar assembly (55) to the mechanism plate with the two XX–X pillar mounting screws (54).

75. Reassembly of Y Magnet and Y Retaining Pawl Assemblies (fig. 18)

a. Y Magnet Assembly.

(1) Insert the Y driving pawl (21) into the neck of the Y armature assembly (8) and fasten it in place with the Y magnet pawl pin (23) and two lock rings (22).

(2) Insert the interrupter bumper mounting bolt (17) through the slot in the arm of the Y armature.

(3) Slide the interrupter bumper washer (20), interrupter bumper bearing (18), interrupter bumper (19), and second interrupter bumper washer (20) over the interrupter bumper mounting bolt, position them in the center of the slot on the Y armature. Fasten them with the interrupter bumper mounting nut (16).

(4) Insert the Y magnet hinge pin (15) into the holes on the Y armature.

(5) Center the hinge pin in the hinge plate (6) and fasten the plate to the Y magnet frame (2) with the two hinge plate mounting screws (5). See that the Y armature moves freely of its own weight.

(6) Insert the two interrupter mounting bolts (12) through the holes in the arm of the hinge plate.

(7) Slide the interrupter assembly (14) and interrupter clamp (13) over the interrupter mounting bolts and fasten to the arm of the hinge plate with the two interrupter mounting nuts (11).

(8) Use the end wrench to fasten the Y magnet coil (10) to the Y magnet frame with the coil mounting screw (9).

(9) Fasten the Y magnet frame to the mechanism plate with the two Y magnet assembly mounting screws (1).

(10) Use long-nosed pliers to replace the retractile spring (7) between the holes of the Y armature and hinge bracket.

(11) Insert the Y armature backstop (4) through the neck of the Y armature.

(12) Hold the Y armature and Y armature backstop down until the holes in the Y armature backstop match the holes in the bracket fastened to the Y magnet frame and fasten the Y armature backstop to the bracket with the two backstop mounting screws (3).

b. Y Retaining Pawl Assembly.

(1) Insert the Y retaining pawl post (28) through the slot of the Y retaining pawl base.

(2) Slide the Y retaining pawl washer (31) over the Y retaining pawl post.

(3) Slide the Y retaining pawl spring (30) over the Y retaining pawl bushing (29), with the straight end of the spring faced down and forward.

(4) Slide the Y retaining pawl spring and bushing between the arms of the Y retaining pawl (32).

(5) Slide the Y retaining pawl, spring and bushing onto the Y retaining pawl post and fasten them with the Y retaining pawl nut (27).

(6) Fasten the Y retaining pawl assembly to the mechanism plate with the two Y retaining pawl assembly mounting screws (25).

Note. The Y retaining pawl engages the serrated teeth of the cog roller assembly, and holds the cog roller assembly in the Y normal position while remaining free to move over the serrated teeth in the X direction.

76. Reassembly of Y Stop Bar and Release Magnet, Spring Combination, and Cable Assemblies

a. Y Stop Bar (fig. 21).

(1) Use long-nosed pliers to insert the stop bar roller (7) into the Y stop bar (5) with the roller clip (6).

(2) Position the right end of the Y stop bar under the Y retaining pawl assembly, moving the bar into position so that both projections engage the slotted holes in the mechanism plate.

(3) Seat the foot retainer (3) over the foot retainer mounting hole.

(4) Position the projection of the stop bar backstop (2) in the square hole in the mechanism plate.

(5) Fasten the foot retainer and stop bar

backstop to the mechanism plate with the stop bar mounting screw (1).

(6) Use long-nosed pliers to replace the stop bar return spring (4).

b. Release Magnet Assembly (fig. 19).

(1) Insert the release magnet hinge pin (8) between the two holes in the hinge bracket (10).

(2) Fasten the hinge bracket to the release magnet armature (5) with the two hinge bracket screws (9).

(3) Center the hinge pin in the hinge plate (4) and secure the plate to the release magnet frame with the two bracket mounting screws (3). See that the armature moves freely of its own weight.

(4) Use the end wrench to fasten the release magnet coil (7) to the release magnet frame (2) with the coil mounting screw (6).

(5) Fasten the release magnet assembly to the mechanism plate with the two release magnet assembly mounting screws (1).

(6) Fasten the spring combination (12) to the release magnet frame with the two spring combination mounting screws (11).

c. Cable Assembly (fig. 21).

Note. The cable assembly consists of nylon-insulated tinsel wire and does not require stripping in the normal way. Thread the wire, leaving a ¼-inch to ½-inch loop, through the eye of the terminal. Fold back and apply heat. Cut off the excess wire when all connections are completed.

(1) Thread the leads through the terminations on the jack block (13) and *carefully* solder. Refer to fig. 22 for location and color coding.

(2) Fasten the cable (15, fig. 21) to the jack block by securing the cable clamp (11) with the two cable clamp screws (10).

(3) Fasten the jack block to the housing (14) with the two plug mounting screws (12).

(4) Separate the cords that go to the three spring wiper assemblies, leaving a sufficient loop to permit the XY switch to move to its most extended position without binding or straining the three cords.

(5) Thread the cord which goes to the XX–X spring wiper assembly (53, fig. 17) through the integral clamp that is a part of the XX–X rack (49), and bend the clamp down until it secures the cord.

(6) Loosen the spring wiper nut (50), and thread the cord under the cable clamp (52).

(7) Fasten with the spring wiper nut.

(8) Thread the conductors ((6) above) through their respective terminals and solder.

(9) Use the cable clip pliers to fasten the two wiper cords to the Y carriage (35, fig. 20) with the cable clip (31).

(10) Loosen the two spring wiper nuts (36) on the two Y carraige spring wipers assemblies (37) and thread the cord under the cable clamp (38).

(11) Fasten with the two spring wiper nuts.

(12) Thread the conductors ((10) above) on each spring wiper through their respective terminals and solder.

(13) Thread the two leads to the interrupter assembly (14, fig. 18) of the Y magnet assembly and the two leads to the interrupter assembly (15, fig. 17) of the X magnet assembly and solder.

(14) Divide the leads into groups for each spring layer of the spring combination assembly, which is loose from mechanism plate.

(15) Refer to figure 22 for location and color coding and thread the leads through the terminals and solder.

(16) Fasten the cable (15) (fig. 21) to the mechanism plate (20) with the two cable clips (8) and two cable clip screws (9).

(17) Check the tines of the 36-point connector plug for alinement and positive pressure on the circuit plate jack.

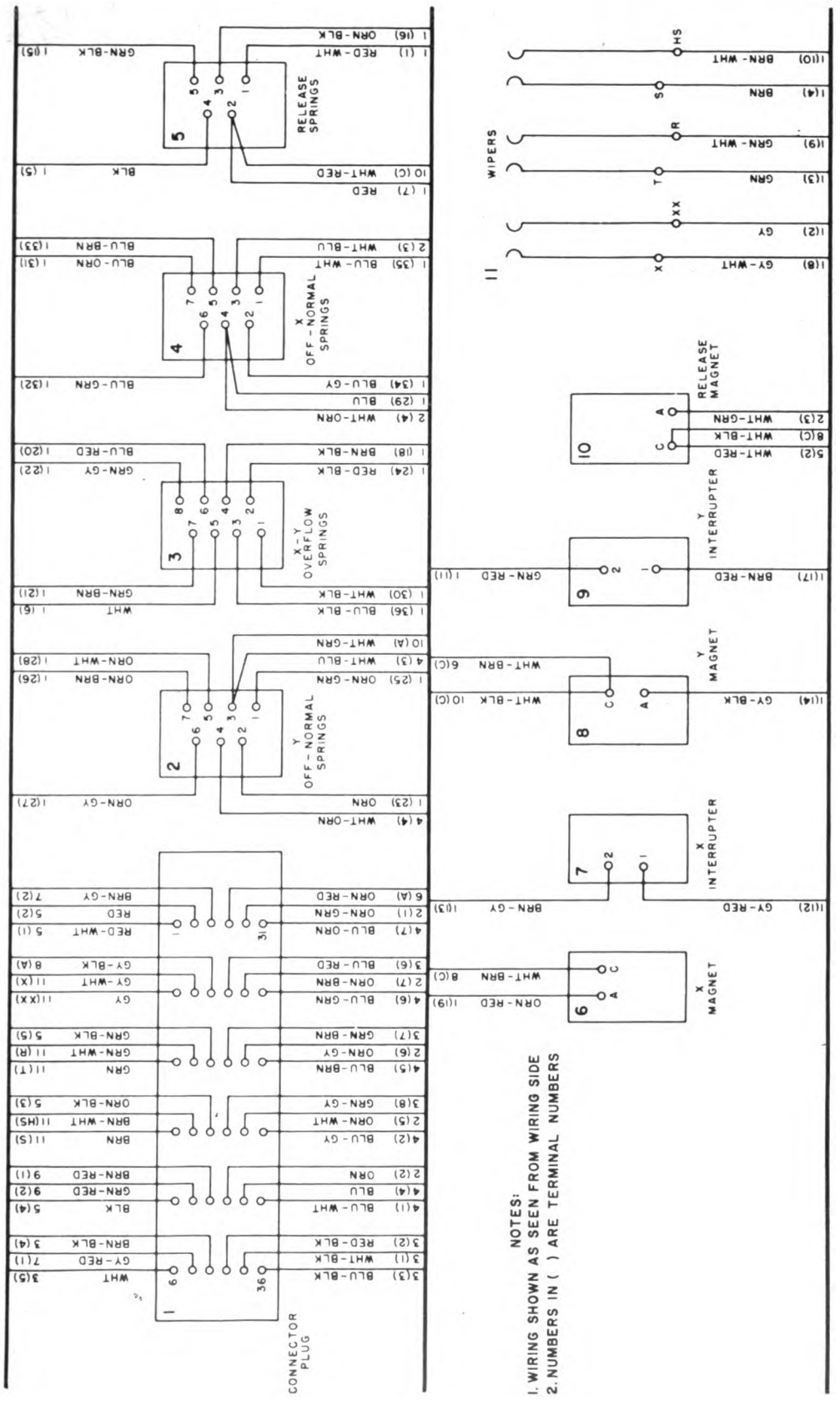


Figure 22. XY switch, wiring diagram.

d. Spring Combination Assembly (fig. 19).

(1) Position the spring combination assembly (14) into place until the toggle lever engages the square hole in the switching lever.

(2) Fasten the spring combination assembly to the mechanism plate with the three spring combination assembly mounting screws (13).

(3) Check to see that all leads are still connected to the terminals.

Section V. ADJUSTMENTS OF XY SWITCH

77. Adjustment, General

When an XY switch is suspected of failure because it is out of adjustment, it should be removed from service and adjusted in accordance with procedures listed below.

Note. Before inserting thickness gages between the armatures and cores of the X and Y magnets, place a strip of masking tape across the magnet terminals. This will prevent blowing fuses when gages are used.

a. Removal.

(1) Restore the switch to its normal (unoperated) position.

(2) Disconnect the connector plug from the circut plate jack.

(3) Depress the locksprings and pull forward, supporting the switch on the palms of the hands.

(4) Remove the switch from its cell.

b. Preparation.

(1) Inspect the switch for signs of wear or broken parts.

(2) Repair or replace the worn or broken parts.

(3) Clean and lubricate the switch.

c. Method.

(1) Make the checks and adjustments described in paragraphs 78 through 93, observing the specifications listed below.

(*a*) Where an adjustment affects an associated part or assembly, both should be checked for proper adjustment before proceeding.

(*b*) Unless otherwise specified, all adjustments should be made to that side of a tolerance that will give the closer fit.

(*c*) Unless otherwise specified, use a thickness gage for all measurements.

(*d*) Unless otherwise specified, manually operate the relays.

(*e*) Unless otherwise specified, use the tools and test equipment supplied (par. 61).

(2) Perform the final testing of the switch (par. 94) and, if the switch meets the requirements, tag it for service.

d. Replacement.

(1) Restore the switch to its normal position.

(2) Slide the switch into its cell.

(3) Check the engagement of the locksprings by tapping the turned-up lip of the mechanism plate with the heel of the hand.

(4) Position the connector plug and push it firmly into the circuit plate jack until fully engaged.

78. Check of Mechanism Plate

a. Check the alinement of the mechanism plate by removing it from its cell and placing it on a flat surface.

b. Use a straightedge or level and check the flatness of the plate.

c. Check the trueness of the plate by siting down the edge of the plate with the eye.

d. No adjustment is possible but a bent or damaged mechanism plate should be replaced.

79. Adjustment of Locksprings

a. Checks.

(1) Lock the XY switch securely in its cell and observe that there is no movement of the mechanism plate during operation.

(2) Check to see that the locksprings do *not* touch the sides of the cell or adjacent parts of the XY switch.

(3) Remove the XY switch from its cell and observe that the locksprings are

parallel to each other and securely fixed in place by the lockspring mounting screws.

b. Adjustment procedures.

(1) Bend the locksprings gently upward for greater pressure or downward for less pressure.

(2) Insert the switch into its cell and check the engagement.

80. Adjustment of X Stepping Mechanism, Normal Position (fig. 23)

Unless otherwise specified, the checks and adjustments listed in *a* through *d* below are accomplished with the XY switch in the normal position.

a. Lineup and Backlash (fig. 24).

(1) *Checks.*

(a) Check to see that the center lines of the index hole, X gear cluster, and engaging tooth are perpendicular to the axis of the cog roller assembly.

(*b*) Check the backlash between the sprocket gear teeth and the mating annular teeth of the cog roller (.000 to .010 inch).

(*c*) Recheck in the X–5 and X–10 positions.

(2) *Adjustment procedure.*

(*a*) Loosen the X gear post nut (fig. 23).

(*b*) Use a thickness gage and reposition the X gear assembly until the requirement listed in (1) above are met.

(*c*) Retighten the X gear post nut securely.

b. X Retaining Pawl Setting.

(1) *Checks.*

(*a*) Check by hand to see that the X retaining pawl moves in and out of engagement with its mating ratchet face with a slight drag.

(*b*) Recheck in other selected X direction positions.

(2) *Adjustment procedure.*

(*a*) Loosen the X retaining pawl post nut and X gear post nut and reseat the ejector strap.

(*b*) If further adjustment is required, loosen the two X retaining pawl assembly base mounting screws and reposition the X retaining pawl assembly base.

(*c*) Retighten the X retaining pawl assembly base screws and X retaining pawl post nut.

(*d*) Recheck the lineup ((1) (*a*) above) on the X gear assembly.

c. X Return Spring Setting.

(1) *Checks.*

(*a*) Check to see that the X return spring will return the XY switch from step X–1/2 on.

(*b*) Check to see that the switch returns to normal from the overflow position.

(2) *Adjustment procedure.*

(*a*) Loosen the windup washer locking screw.

(*b*) Wind the X return spring approximately 10 to 14 notches.

(*c*) Retighten the windup washer locking screw.

d. Armature Backstop Setting (fig. 23).

(1) *Checks.*

(*a*) Check to see that the X-drive pawl has a .002 inch minimum radial clearance from the outside diameter of the ratchet gear.

(*b*) Recheck the position of the ejector strap.

(2) *Adjustment procedure.*

(*a*) Loosen the armature backstop mounting screws.

(*b*) Reposition the armature backstop.

(*c*) Retighten the screws after adjustment.

81. X Stepping Mechanism, Off-Normal Position (fig. 23)

The check and adjustments listed in *a* through *e* below are performed with the XY switch test set. (TM 11–2120). The test set energizes the X magnet coil. This action will step the XY switch in the off-normal (operated) position.

a. X Armature Assembly, Air Line Setting.

(1) *Checks.* The clearance airline between the end of the X magnet frame and

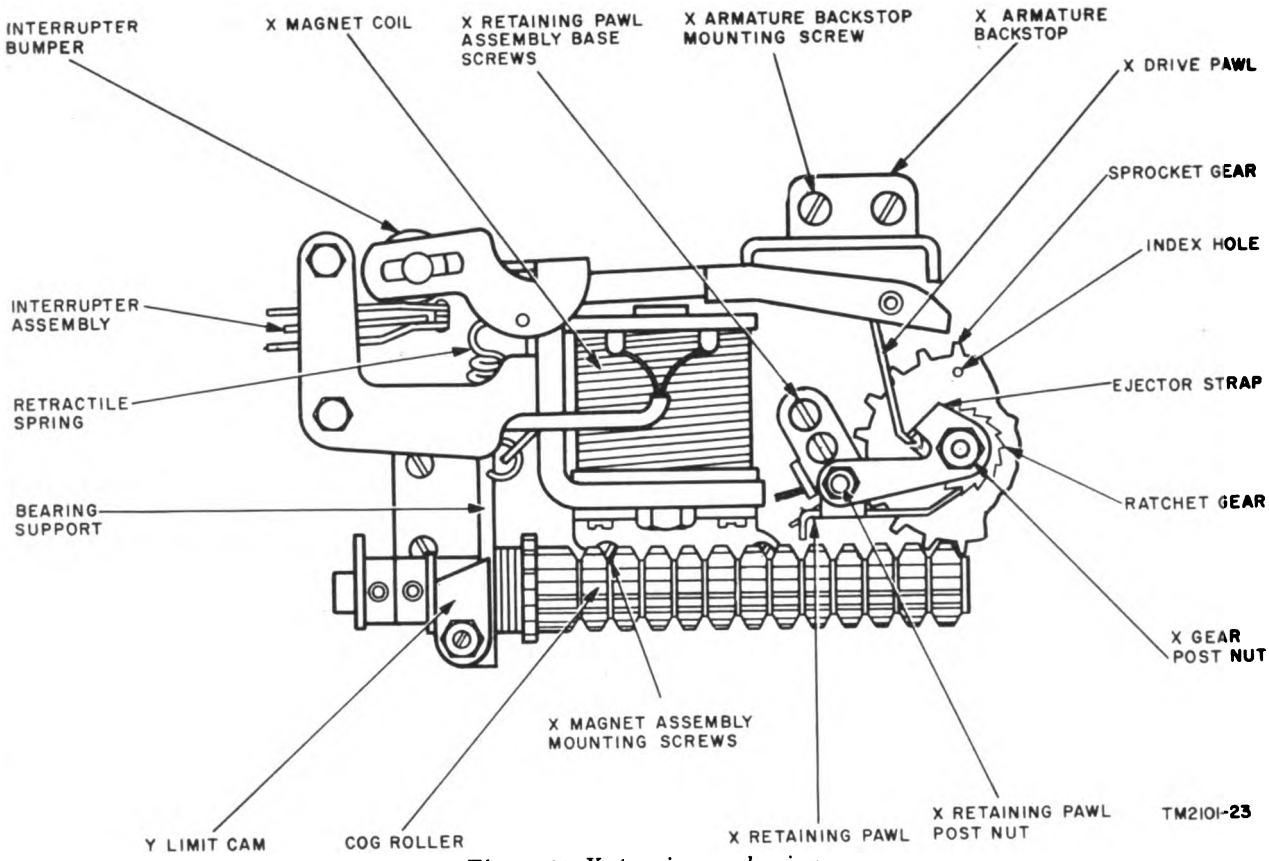


Figure 23. X stepping mechani m.

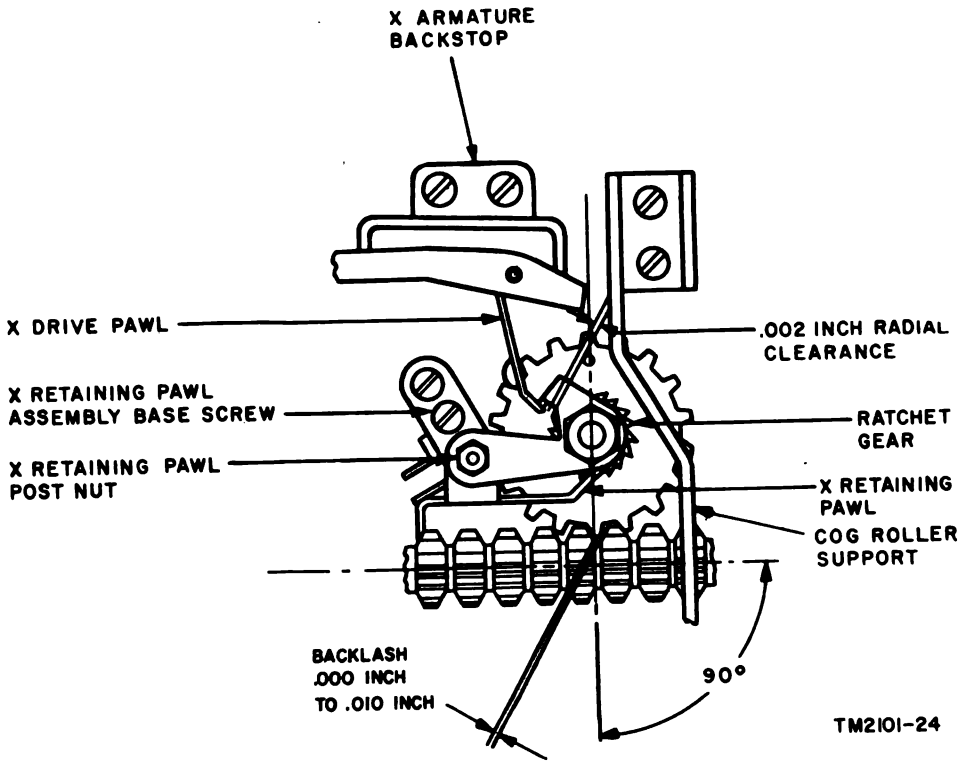


Figure 24. X magnet driving action.

X armature assembly should be held to a minimum and should be barely perceptible (.00.5 inch).

(2) *Adjustment procedure.*

(*a*) Loosen the two hinge bracket mounting screws.

(*b*) Allow the X armature assembly to seat itself in the correct position.

(*c*) Retighten the two screws.

b. Drive Pawl, X Driving Action (fig. 25).

(1) *Checks.* The X drive pawl must engage the flank of the ratchet gear on the X gear assembly before coming in contact with the radial face. This point of engagement should be three-quarters of the rise of the tooth on the ratchet gear.

(2) *Adjustment procedure.*

(*a*) If the setting of the ejector strap is unsatisfactory (par. 80*b*), loosen the two X magnet assembly mounting screws (fig. 13) and shift it to the proper position.

(*b*) If the ejector strap has been disturbed, loosen the X gear post nut and X retaining pawl post nut and reposition the ejector strap.

(*c*) After adjustment, retighten the screws.

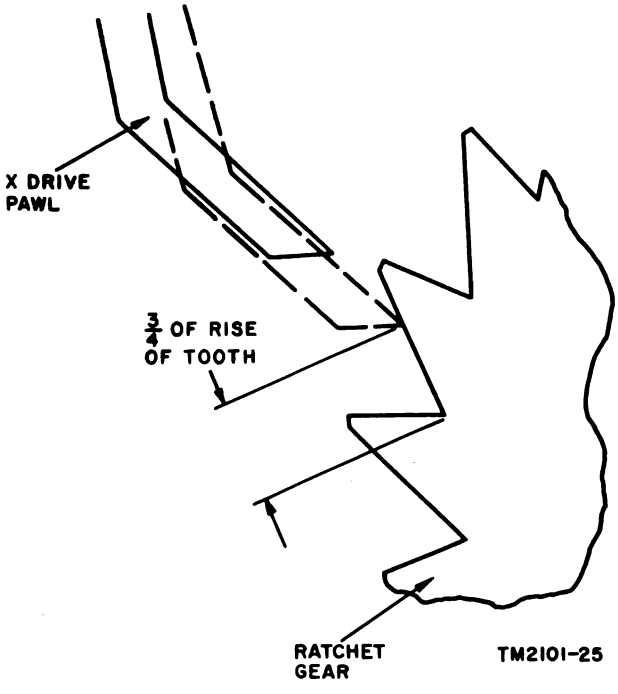


Figure 25. X drive pawl engagement.

c. X Stopping Action (fig. 26).

(1) *Checks.* With the X retaining pawl in full engagement, the distance between the end of the X armature assembly and its mating tooth on the sprocket gear must be between .000 inch and .010 inch. To assure more positive stopping action, at least three-quarters of the material thickness of the armature channel must engage the sprocket gear tooth.

(2) *Adjustment procedure.*

(*a*) Loosen the two X magnet assembly mounting screws.

(*b*) Move the X magnet assembly on the mechanism plate until the X magnet assembly meets the requirements listed in (1) above.

(*c*) Check to make sure that the X armature assembly does not interfere with the preceding sprocket gear tooth during the stepping operation.

(*d*) Retighten the screws after adjustment.

d. X Short Pawl Action (fig. 27).

(1) *Checks.* After the X drive pawl reaches the end of its stroke, the X gear cluster continues to rotate because of the momentum until it is stopped by the sprocket gear that engages the X armature assembly channel. This is known as the *X short pawl action.* To check the amount of X short pawl,

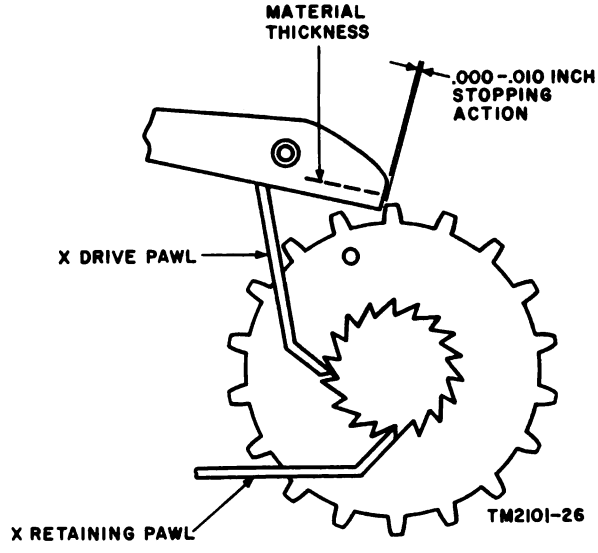


Figure 26. X stopping action.

hold the X magnet assembly operated and pull the X retaining pawl out of engagement with the ratchet gear. This causes the X gear assembly and cog roller to drop back. The short pawl measurement between the X armature assembly and the tooth of the sprocket gear should be between .000 inch and .050 inch (preferably .030 inch to .040 inch).

(2) *Adjustment procedure.*

(*a*) Loosen the two X magnet assembly mounting screws.

(*b*) Move the X magnet assembly toward or away from the X gear assembly.

(*c*) If necessary, adjust the X armature assembly in or out by using the spring adjuster tool.

e. Interrupter Assembly Setting.

(1) *Checks.*

(*a*) Release the XY switch.

(*b*) Insert a .003 inch thickness gage between the X armature assembly and core of the X magnet coil and operate the X magnet armature (manually or electrically). The contact springs should just break.

(*c*) When a .006 inch thickness gage is used, the contact springs should remain closed.

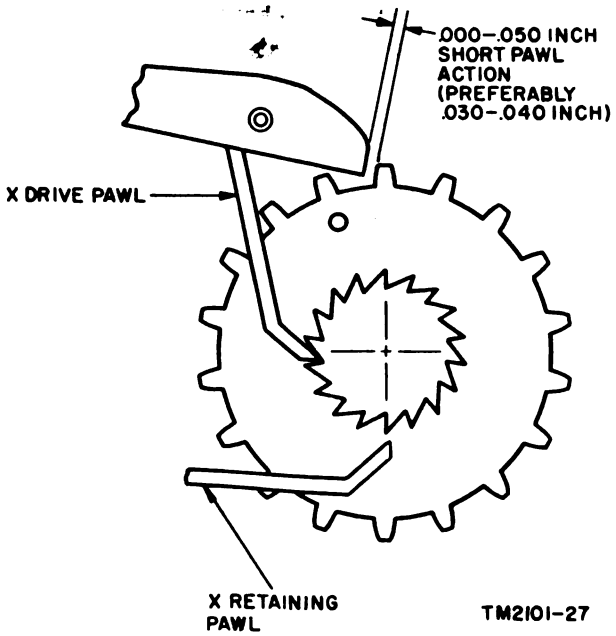


Figure 27. X short pawl action.

(*d*) Connect a buzzer across the contact springs of the interrupter assembly to determine whether the contacts are making or breaking.

(2) *Adjustment procedure.*

(*a*) Loosen the interrupter bumper nut slightly.

(*b*) With the interrupter adjusting pliers, rotate the interrupter bumper. Make sure the interrupter bumper strikes the contact spring just behind the rivet head when the X magnet is energized.

(*c*) Tighten the interrupter bumper nut being careful not to shift the position of the interrupter bumper.

82. Adjustment of Y Stepping Mechanism, Normal Position (fig. 28)

Unless otherwise specified, the checks and adjustments listed in *a* through *f* below are performed with the XY switch in its normal (unoperated) position.

a. Y Return Spring Assembly Tension.

(1) *Checks.*

(*a*) Check to see that the Y return spring assembly returns the XY switch to normal from Y–½ position.

(*b*) Check to see that the XY switch returns to normal from the Y-overflow level at all X positions (manually or electrically).

(2) *Adjustment procedure.*

(*a*) Loosen the Y return spring lock screw and release all tension on the spring.

(*b*) Turn the Y return spring assembly in a clockwise direction 8 to 9½ turns.

(*c*) Retighten the Y return spring lock screw.

Note. Do not remove the screwdriver from the Y return spring screw until the Y return spring lock screw is tightened.

b. Digit Drum, End Play Setting (fig. 29).

(1) *Checks.* The end play of the tubular shaft is checked by butting the Y stop collar against the bearing support and measuring the clearance between the

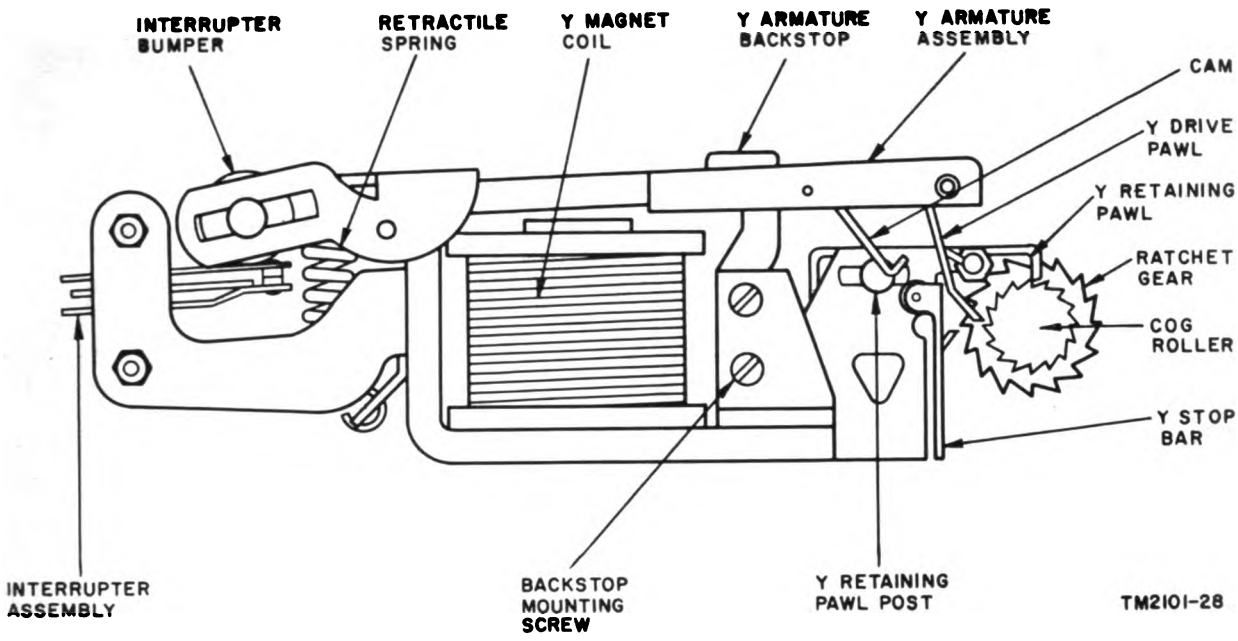


Figure 28. Y stepping mechanism.

left side of the digit drum and the left wall of the right yoke. This measurement should be .004 inch to .010 inch and is identified as the permissible degree of end play in the tubular shaft.

(2) *Adjustment Procedure.*

(*a*) Loosen the two digit drum setscrews.

(*b*) Relocate the digit drum and make sure the digit drum is located so that the individual Y steps are registered slightly above the right end of the guide rule without showing the number below.

(*c*) Retighten the two setscrews.

c. Y Stop Bar Setting (fig. 30).

(1) *Checks.* The foot retainer exerts only enough force against the left foot of the Y stop bar to maintain it against the back edge of the Y stop bar hole (in the mechanism plate) during operation. The force should not prevent the Y stop bar from returning properly to its seated position against

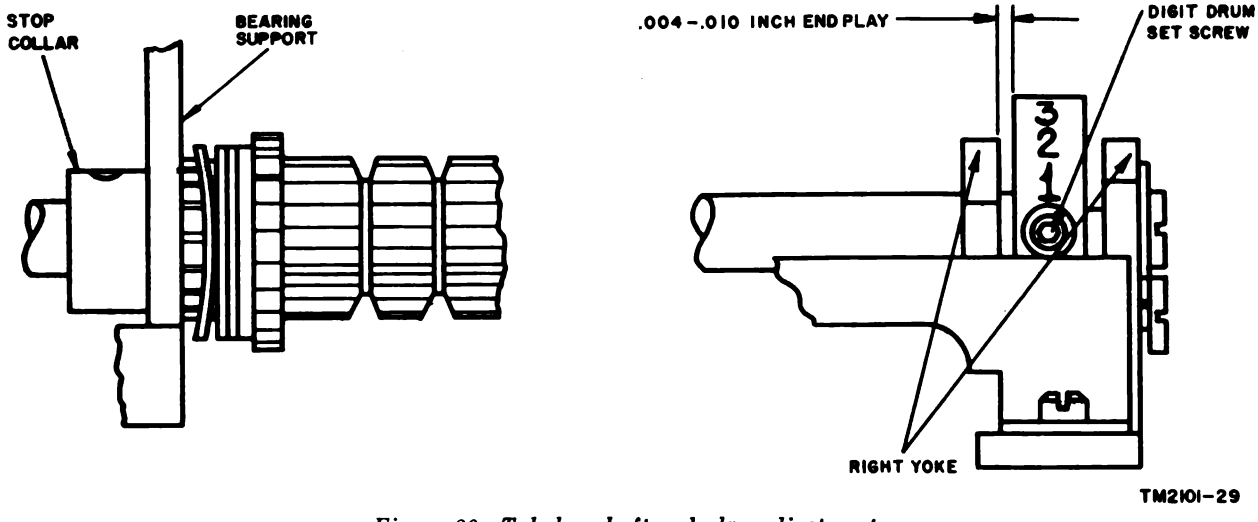


Figure 29. Tubular shaft end play adjustment.

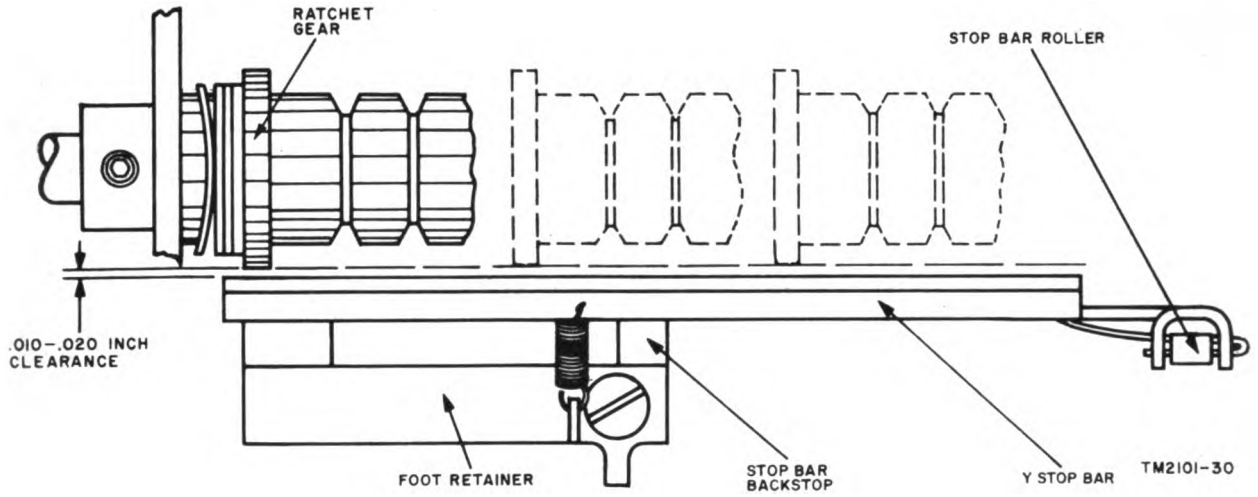


Figure 30. Y stop bar adjustment.

the stop bar backstop. In this position, the Y stop bar should clear the periphery of the ratchet gear by .010 inch to .020 inch in all X and Y positions.

(2) *Adjustment procedure.* To adjust for proper clearance, bend the stop bar backstop in or out to meet the requirements described in (1) above.

d. Y Stop Setting (fig. 31).

(1) *Checks.* With the XY switch in the Y normal position, the Y stop should rest against the Y stop screw so that the Y stop bar may be moved into and out of engagement with the ratchet gear with a slight drag and a clearance of .000 inch to .010 inch between the engaging faces.

(2) *Adjustment procedure.*

(*a*) Loosen the locknut.

(*b*) With the Y stop bar fully engaging the ratchet gear, adjust the Y stop screw until the Y stop bar meets the requirements described in (1) above.

(*c*) Retighten the locknut.

e. Y Retaining Pawl Setting (fig. 32).

(1) *Checks.*

(*a*) Check to see that the Y retaining pawl latches over the top of and into engagement with the associated serrated tooth of the cog roller with little or no backlash or drop-back as

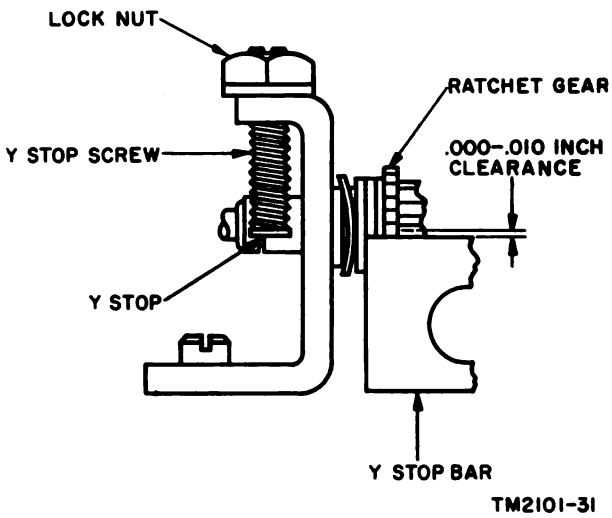


Figure 31. Y stop adjustment.

the pawl is withdrawn at the tenth operating step.

(*b*) At Y normal, the tangential clearance between the Y retaining pawl and the root of its mating tooth should be .000 inch to .015 inch.

(*c*) At Y normal, the radial clearance between the Y retaining pawl and root of the tooth should be .000 inch to .010 inch.

Note. Some clearance is desired in (*b*) and (*c*) above, for if the Y retaining pawl should ride in the root of the serrated tooth, the X speed would be retarded.

(2) *Adjustment procedure.*

(*a*) Use the spring adjuster to bend the

actuating arm of the release magnet hinge bracket in or out for the clearance specified in (*c*) above.

(*b*) Loosen the Y retaining pawl nut and reposition the Y retaining pawl for the tangential clearance specified in (1) (*b*) above.

(*c*) Retighten the Y retaining pawl nut and try for the same clearance specified in (1) (*b*) and (*c*) above at two or three other X levels chosen at random. If necessary, readjust at these new positions until a proper compromise has been achieved.

f. Y Armature Backstop Setting (fig. 28).

(1) *Checks.* The location of the Y armature backstop should be set so the Y driving pawl has a .002-inch minimum radial clearance from the outside diameter of the serrated teeth of the cog roller.

(2) *Adjustment procedure.*

(*a*) Adjust for the proper minimum or greater radial clearance by loosening the two backstop mounting screws.

(*b*) Reposition the Y armature backstop up or down for the minimum radial clearance.

(*c*) Retighten the screws.

83. Adjustment of Y Stepping Mechanism, Off-Normal Position (fig. 28)

The checks and adjustments listed below are performed with the Y magnet coil energized by a 24-volt dc source (par. 104). This action will place the XY switch in the off-normal position.

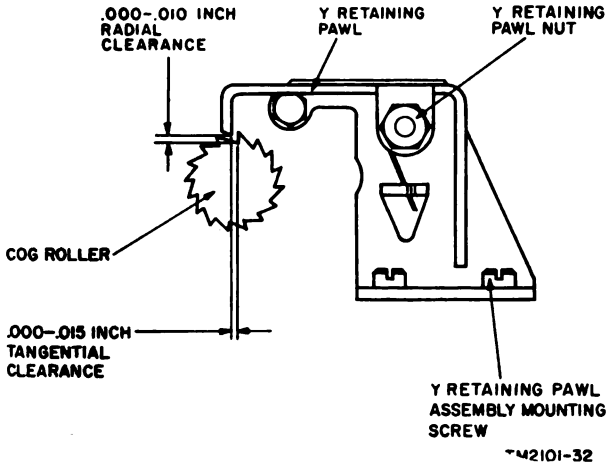


Figure 32. Y retaining pawl setting.

a. Y Armature Assembly, Air Line Setting.

(1) *Checks.* The clearance (*air line*) between the end of Y magnet frame and the Y armature assembly should be barely perceptible (.0015 inch).

(2) *Adjustment procedure.*

(*a*) Adjust by loosening the two hinge plate mounting screws and allowing the Y armature assembly to seat itself in the correct position.

(*b*) Retighten the two screws.

b. Pawl, Y Driving Action (fig. 33).

(1) *Checks.* The Y driving pawl must engage the flanks of the serrated teeth of the cog roller before coming in contact with the radial face. This point of engagement is limited to a section from the root to three-quarters the length of the flank.

(2) *Adjustment procedure.*

(*a*) Loosen the two Y magnet assembly mounting screws.

(*b*) Reposition the Y magnet assembly on the mechanism plate.

(*c*) Retighten the two screws.

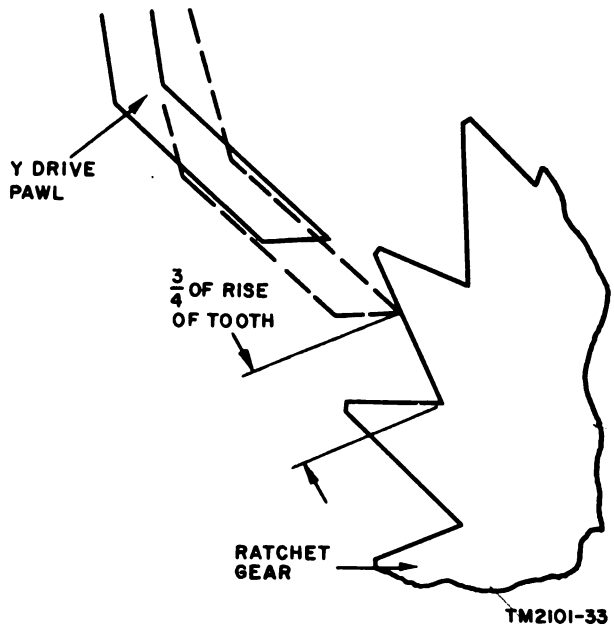


Figure 33. Y pawl engagement.

c. *Y Stopping Action* (fig. 34).

(1) *Checks.*

(*a*) Check to see that the cam on the underside of the Y armature assembly is adjusted to drive the Y stop bar forward while the pawl is advancing the XY switch in the Y direction.

(*b*) Check to see that the Y stop does not strike the bottom of the ratchet gear tooth, but advances to a position where the tooth has an engagement of from .020 inch to .040 inch with the stop bar.

(*c*) Check to see that the Y driving pawl engages the serrated teeth of the cog roller before the cam moves against the stop bar roller. Under these conditions, the cog roller will start rotating before the cam engages the roller.

(2) *Adjustment procedure.*

(*a*) Loosen the two Y magnet assembly mounting screws.

(*b*) Reposition the Y magnet assembly.

(*c*) If the clearance and actions noted in (1) (*a*) through (*c*) above still cannot be met, use the spring adjuster tool to bend the cam to the desired position.

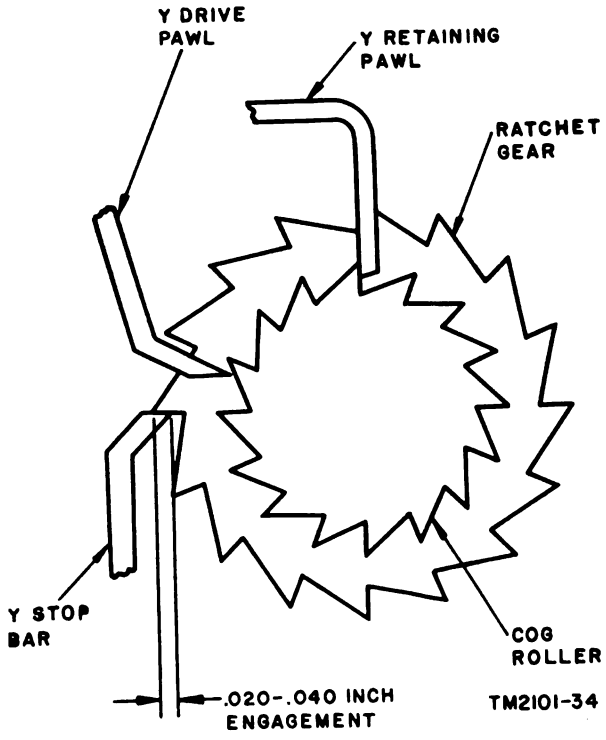


Figure 34. Y stopping action.

d. *Y Short Pawl Action* (fig. 35).

(1) *Checks.* After the pawl reaches the end of its stroke, the cog roller continues to rotate because of momentum, until it is stopped by the Y stop bar engaging the ratchet gear. This movement is known as the *Y short pawl action.* To measure the amount of Y short pawl action, release the Y retaining pawl. The short pawl measurement should then be .000 inch to .025 inch.

(2) *Adjustment procedure.*

(*a*) Loosen the two Y magnet assembly screws.

(*b*) Move the Y magnet assembly toward or away from the cog roller to obtain the short pawl measurement.

(*c*) If necessary, bend the Y armature assembly up or down by using the spring adjuster tool.

(*d*) Retighten the two screws.

e. *Interrupter Assembly Setting.*

(1) *Checks.*

(*a*) Deenergize the switch.

(*b*) Insert a .003 inch thickness gage between the Y armature assembly and the pole piece of the Y magnet coil and operate the Y magnet armature (manually or electrically). The contact springs should just break.

(*c*) When a .006 inch thickness gage is used, the contact springs should remain closed.

(*d*) Connect a buzzer across the contact springs of the interrupter assembly to determine whether the contacts are making or breaking.

(2) *Adjustment procedure.*

(*a*) Loosen the interrupter bumper nut only slightly.

(*b*) Use the interrupter adjusting pliers to rotate the interrupter bumper. Make sure that the interrupter bumper strikes the contact spring

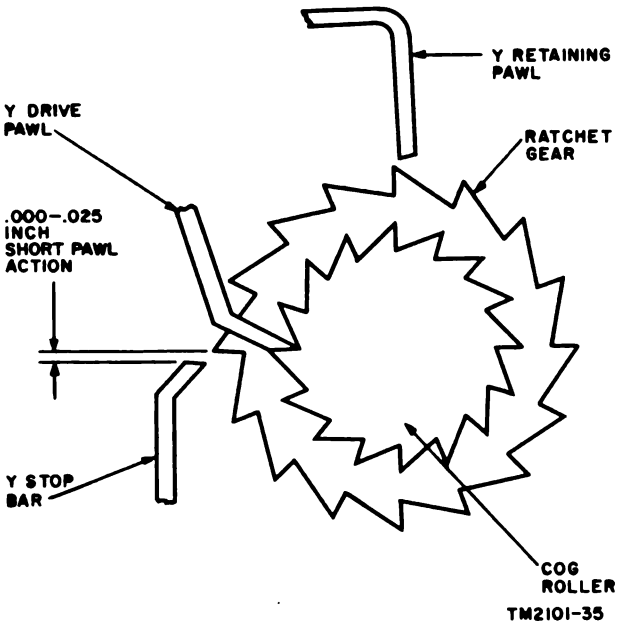


Figure 35. Y short pawl action.

just behind the rivet head with the Y magnet energized.

(*c*) Tighten the interrupter bumper nut; be careful not to shift the position of the interrupter bumper.

84. Adjustment of Cog Roller Support (fig. 24)

a. Checks. The cog roller support should be checked for binds or drags that may occur as the cog roller assembly is stepped in both the X and Y directions. A slight rubbing is permissible.

b. Adjustment Procedure.

(1) To raise the cog roller support, loosen the front cog roller support screw and tighten down on the back one.

(2) To lower the cog roller support, reverse the procedure.

(3) To move forward or backward, loosen both cog roller support screw and reposition as required to meet the requirements described in *a* above.

85. Adjustment of XX–X Pillar Assembly (fig. 36)

a. Checks.

(1) Check to see that the XX–X pillar assembly is centered with the XX–X wire bank and clears the wires by approximately .040 inch.

(2) Check to see that the pillar is perpendicular to the mechanism plate, with the center of the nylon pillar ±.005 inch from the center line.

b. Adjustment Procedure.

(1) Loosen the two XX–X pillar mounting screws.

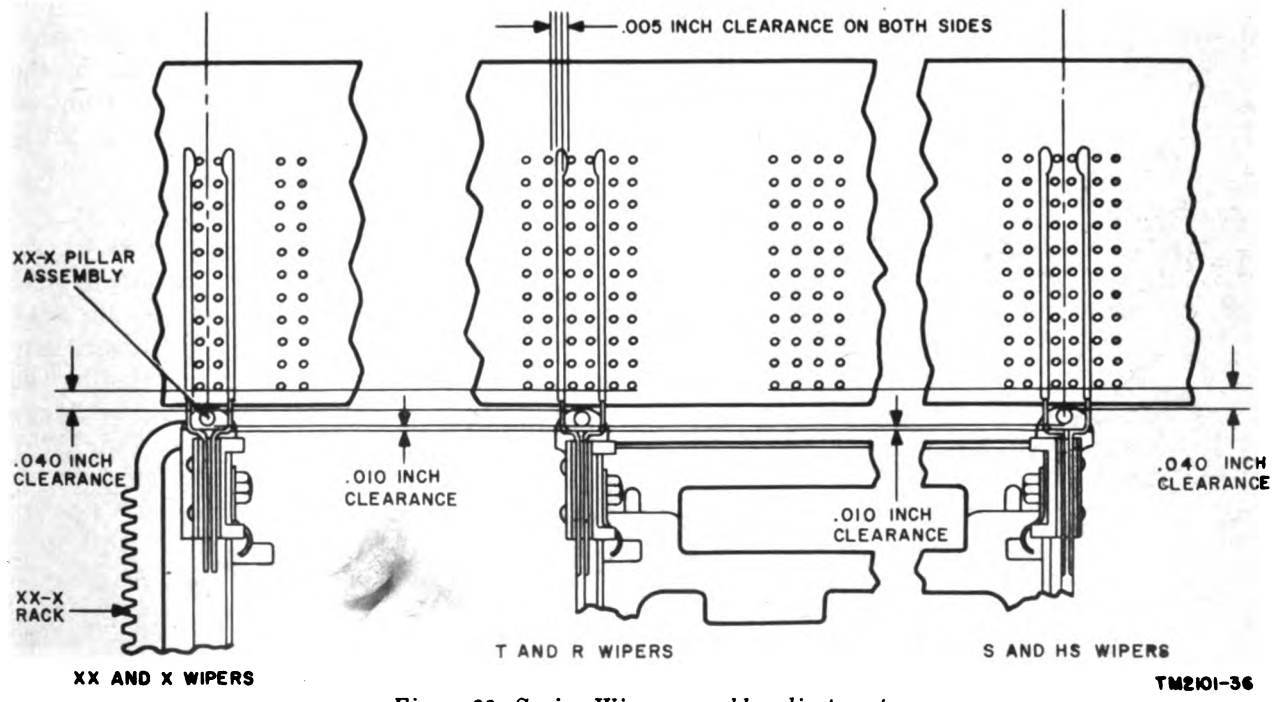


Figure 36. Spring Wiper assembly adjustment.

(2) Reposition the pillar to meet the requirements described in *a*(1) and (2) above.
(3) Retighten the two screws.

86. Adjustment of XX–X Rack Assembly (fig. 36)

a. Checks.

(1) Check to see that the XX–X rack assembly meshes with the bell cup gear in such a way as to permit free motion without binding.
(2) Check to see that the backlash (fig. 24) between the bell cup gear and the rack teeth measures from .000 inch to .010 inch.
(3) Check for proper engagement of the assembly with the bell cup gear by observing the elongated slot of the XX–X rack assembly. The back of the slot should be ready to disappear under the rack way screw as the XY switch returns to its X normal position.

b. Adjustment Procedure.

(1) Loosen the two base mounting screws.
(2) Reposition the base mounting to meet the requirements described in *a*(1) through (3) above. Be careful not to nick or bend the rack during adjustment.
(3) Retighten the two screws.

87. Adjustment of X Carriage Assembly (fig. 37)

a. Checks.

(1) See that the four feet of the X carriage assembly have the same clearance from the mechanism plate. A limited amount of rocking motion has been built into the X carriage assembly. To check the clearance, press the cable side of the carriage until the feet are seated. Then measure the gap between the feet and the mechanism plate on the opposite side. This gap should not exceed one-thirty-seconds of an inch, as checked visually.
(2) See that the insulated nylon pillars fastened to the carriage clear the front of the wire banks by .040 inch (fig. 36) and are perpendicular to the mechanism plate.

b. Adjustment Procedure.

(1) Use the spring adjuster tool to adjust the feet up or down to meet the requirements described in (1) above.
(2) Use the spring adjuster tool to adjust the insulated-nylon pillars to meet the requirement described in (2) above. This adjustment should be made on the metal bracket that holds the pillar, not the pillar itself.

88. Adjustment of Pinion Assembly (fig. 38)

a. Checks.

(1) See that the notched flange of the pinion assembly rides from .020 inch to .040 inch above the notched guide rule when the XY switch is stepped in the X direction and approximately midway between the notches in the guide rule when stepped in the Y direction.
(2) See that the insulated pillars which are fastened to the X carriage assembly lie within approximately .010 inch (as determined visually) of the center line of their associated wire bank. This last position is determined by the placement of the pinion assembly on the sleeve portion of the cog roller assembly.

b. Adjustment Procedure.

(1) Loosen the six pinion setscrews.
(2) Reposition the pinion assembly to meet the requirements described in *a*(1) and (2) above. The adjustment may also be made by straightening or slightly bending the mounting flange of the X carriage assembly (par. 87*b*) which mount the insulated pillars.
(3) Retighten the six setscrews.

89. Adjustment of Guide Rule (fig. 38)

a. Checks.

(1) See that the guide rule is located on

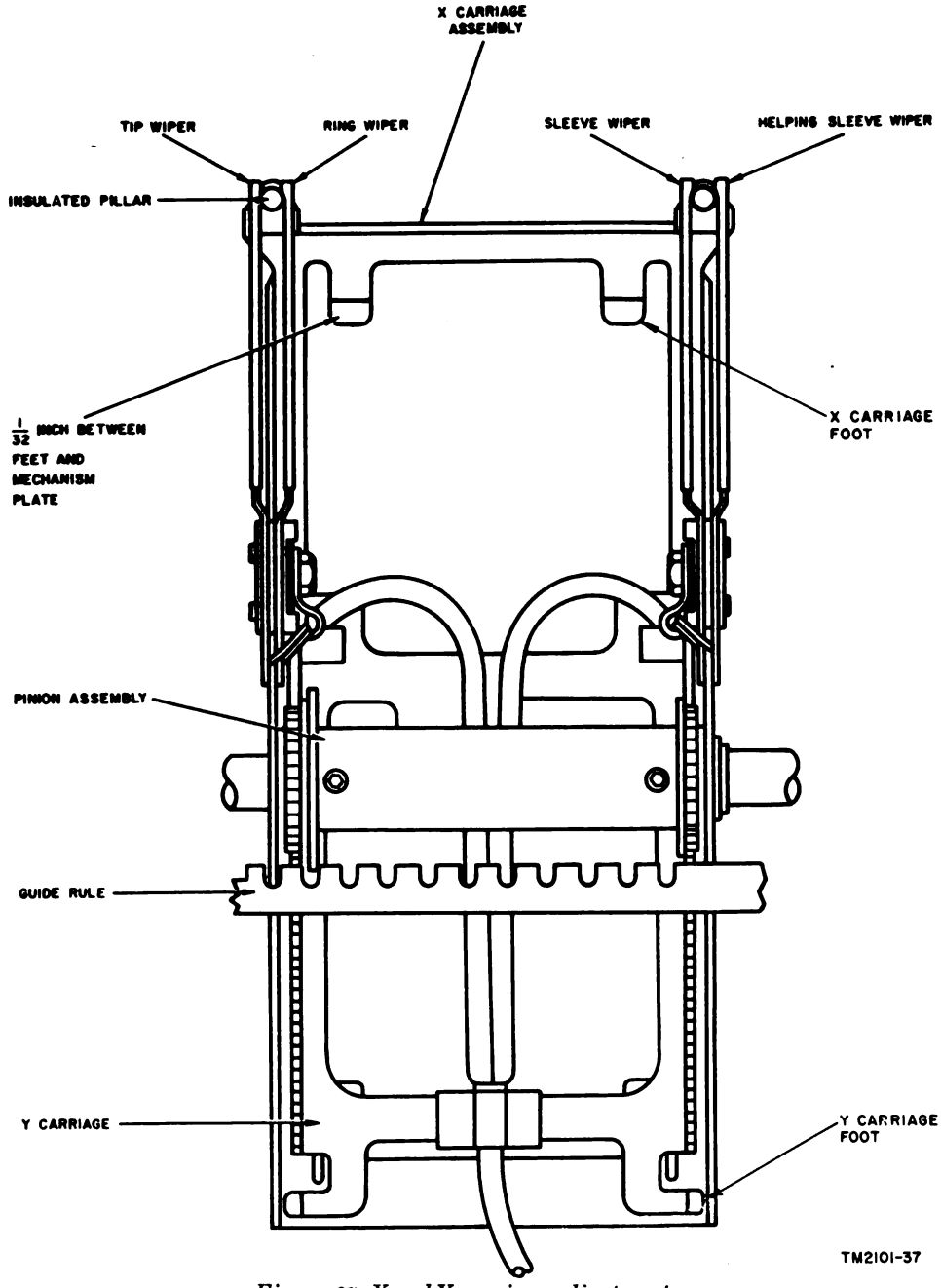


Figure 37. X and Y carriage adjustments.

the mechanism plate so that it engages the notched flange of the pinion assembly by .020 inch minimum.

(2) When the XY switch is stepped in the Y direction, check to see that the notched flange clears the sides of the notches in the guide rule by approximately .010 inch, as determined visually.

b. Adjustment Procedure.

(1) Loosen the right bearing screw (front) and guide rule mounting screw.

(2) Reposition the guide rule to meet the requirements in *a*(1) and (2) above. Be careful not to burr the guide rule mounting screw because it may snag the cable.

(3) Retighten the two screws.

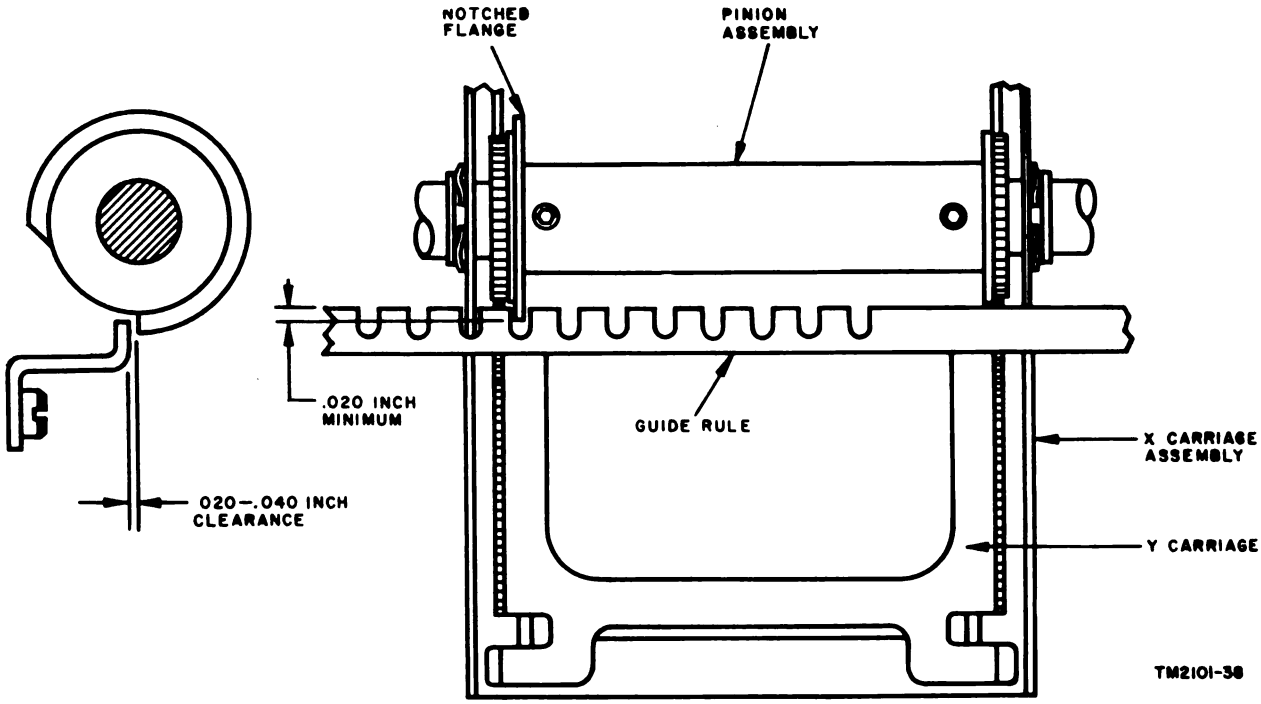


Figure 38. Pinion assembly adjustments.

90. Adjustment of Y Carriage (fig. 37)

a. Checks.

(1) See that the Y carriage rides in the X carriage assembly with no binding at any point of travel in the Y direction.

(2) Check the backlash between the Y carriage teeth and the pinion teeth. It should not exceed .010 inch.

(3) Check to see that the front edge of the Y carriage is between $\frac{1}{64}$ inch and $\frac{3}{64}$ inch from the front of the X carriage assembly at the Y normal position.

b. Adjustment Procedure.

(1) Detach the Y carriage and reseat.

(2) Use the adjuster tool to reform the feet of the Y carriage up or down to meet the requirements listed in *a*(1) and (2) above.

91. Adjustment of Wiper Assemblies (fig. 36)

The XY switch test set is used to check the alinement of the pillars and wipers to the wire bank. To reduce the effect of accumulated tolerances, step the carriage to the positions and perform the checks listed in *a* below.

a. Checks.

(1) Step the carriages to the X5–Y1 positions; see that the flat contact area of the wiper assemblies are centered on the first pair of wires in the bank.

(2) Step the carriages to the Y–5 and Y-overflow; check to see that the insulated sides of the wiper assemblies clear the wire bank wires on both sides by a minimum of .005 inch.

(3) Step the carriages to the X–5 and Y-overflow position, see that the U-portion of the wiper assemblies clear the insulated pillar by .010 inch all around.

(4) Step the carriages to the X–5 and Y-normal positions; check to see that the flat contact area of the wiper assemblies is centered on the insulated pillars, as determined visually.

(5) See that each tine of each spring wiper assembly exerts 15 to 45 grams of pressure on the insulated pillar.

Use the push-pull gram gage to make this check.

b. Adjustment Procedure.

(1) To adjust the flat contact area of the wiper assemblies (*a*(1) above), loosen the spring wiper nut and reposition the wiper assembly. Retighten the screw after adjustment.

(2) To adjust the wiper assemblies for the proper clearance in the wire bank (*a*(2) above), apply tension into or take tension out of the wipers; use the spring adjuster tool.

(3) To adjust the wiper assemblies for proper clearance of the insulated pillars (*a* (3) above), loosen the locknut and reposition the Y limit cam to control the travel of the carriage in the Y direction (fig. 23).

(4) To center the wiper assemblies on the insulated pillars (*a*(4) above), use the spring adjuster tool to bend the flange which mounts the insulated pillar.

(5) To adjust the pressure of the tines on the wiper assemblies (*a*(5) above), use the spring adjuster tool and tension the tines.

92. Adjustment of Release Mechanism (fig. 39)

a. X Releasing.

(1) *Check.* With release magnet armature operated (electrically or manually), check to see that the extension arm of the hinge bracket causes the X retaining pawl to disengage and clear the periphery of its associated ratchet tooth by a minimum of .010 inch. Before the X retaining pawl is fully disengaged from the ratchet gear tooth, the make contacts of the release springs should close.

(2) *Adjustment procedure.*

(*a*) Loosen the two release magnet assembly screws.

(*b*) Reposition the release magnet assembly on the mechanism plate to meet the requirements listed in (1) above.

(*c*) Retighten the two screws.

b. Clearance.

(1) *Checks.* With the XY switch in the X–1 through X–10 positions, the extension arm of the hinge bracket that releases the X retaining pawl should move freely in the slot of the Y stop bar.

(2) *Adjustment procedure.* To adjust for the proper clearance, use the spring adjuster tool to bend the extension arm up or down until it meets the requirement listed in (1) above.

c. Y Releasing.

(1) *Checks.* With the release magnet armature operated (electrically or manually), the extension arm of the hinge bracket should operate the Y retaining pawl so that it clears the serrated teeth of the cog roller by .003 inch to .010 inch.

(2) *Adjustment procedure.* To adjust for the proper clearance, use the spring adjuster tool and bend the extension arm forward or backward until it meets the requirements listed in (1) above.

93. Adjustment of Spring Combination (Release Springs) (fig. 40)

a. Checks.

(1) There should be .005 inch to .008 inch clearance between contacts.

(2) Both halves of the bifurcated springs should make and break in unison as determined visually.

(3) All break contacts should open before make contacts close.

(4) There should be 25 to 55 grams of pressure for each pair of contacts of the bifurcated springs.

b. Adjustment Procedure.

Note. Adjustments are limited to bending the unsupported end of the clamp plate and to bending the light contact springs. The heavy contact springs are not to be disturbed.

(1) To increase the make pressure uniformly, use the adjusting tool to bend the clamp plate downward.

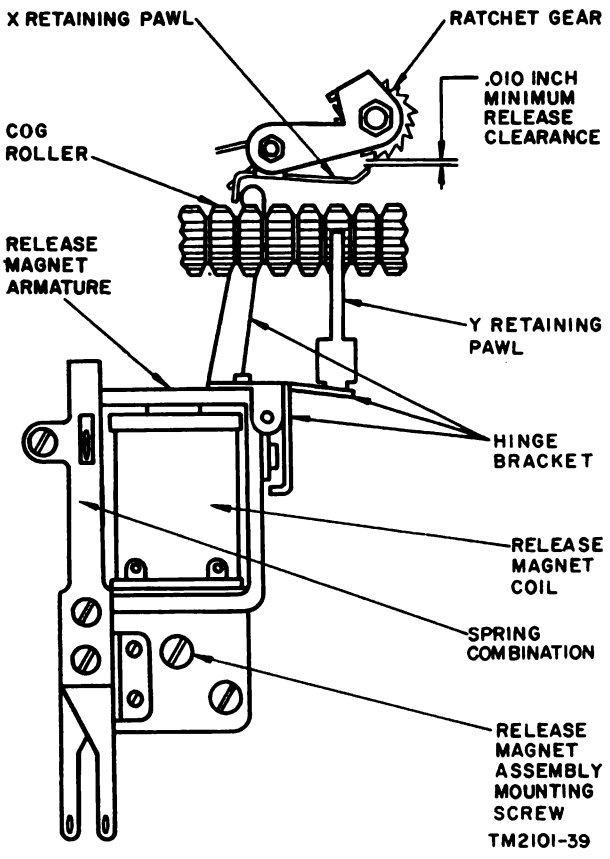


Figure 39. Release magnet mechanism.

(2) To adjust the light spring, use the spring adjuster tool to bend (tension) to light spring.

(3) To measure contact pressures, use the push-pull gram gage.

94. Adjustment of Spring Combination Assembly (Y Off-Normal Springs, X–Y Overflow Springs, and X Off-Normal Springs) (fig. 40)

a. X Off-Normal and X–Y Overflow Springs.

(1) *Checks.*

(*a*) The spring pileups should meet the same requirements as those listed in paragraph 93*a*.

(*b*) In the normal position, the toggle lever should exert only slight pressure on the upper sides of the actuating lever (part of the spring pileups). In this position, the clearance between the light contacts and the associated pusher arms should not exceed .005 inch.

(*c*) With the XY switch between X normal and X–¾ position, the X off-normal springs should release by the toggle lever.

(*d*) With the XY switch between X–10¼ and XX11 positions, the X–Y overflow springs should operate by the toggle lever. With the XY switch between the Y–10½ and Y–11 positions, the X–Y overflow spring should be operated by the X–Y overflow cam.

(2) *Adjustment procedures.*

(*a*) The adjustments should be accomplished in accordance with the instructions listed in paragraph 93*b*.

(*b*) To adjust the actuating lever ((1) (*b*) above), use the spring adjuster tool.

Note. Be careful not to distort the actuating lever clips nor to break the pushers.

(*c*) To adjust for proper releasing ((1) (*c*) above), loosen the three spring combination assembly mounting screws and reposition the spring combination assembly on the mechanism plate so that the switching lever moves freely without interference by the toggle lever. After adjustment, retighten the three screws.

(*d*) To adjust for proper cam operation of the X–Y overflow springs ((1) (*d*) above), loosen the two cam setscrews and reposition the cam. After adjustment, retighten the two cam setscrews.

b. Off-Normal Spring.

(1) *Checks.*

(*a*) The spring pileup should meet the same requirements listed in paragraph 93*b*.

(*b*) The Y off-normal cam should release the spring pileup when the XY switch is between the Y normal and Y–½ positions.

(2) *Adjustment procedures.*

(*a*) The adjustments should be accomplished in accordance with the instructions listed in paragraph 93*b*.

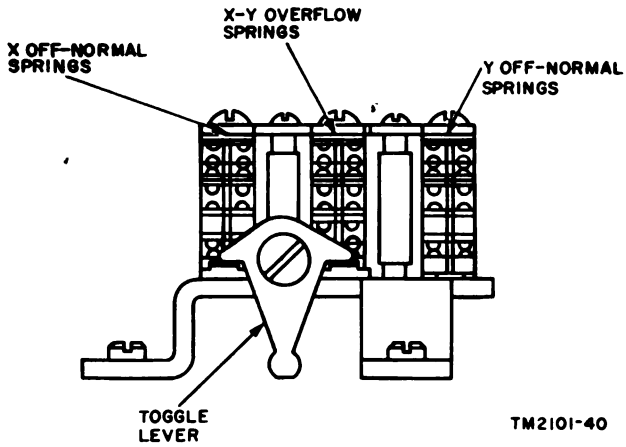


Figure 40. Spring combination assembly.

(*b*) To adjust for proper cam release of the Y off-normal spring, loosen the two cam setscrews in the Y off-normal cam and reposition. After adjustment, retighten the two cam setscrews.

95. Final Testing

Final testing of the XY switch is accomplished through the use of the switch test set. For instructions regarding operation of the XY switch test set, refer to TM 11–2120.

a. Preliminary Operating Instructions.

(1) Remove the cover of the test set.

(2) Move all the lever switches to their center (normal) positions.

(3) Move the ON-OFF switch to the OFF position.

(4) Restore the switch wipers to normal before inserting the switch into the test cell to prevent damage to the switch wiper assemblies and the wire banks of the test set.

(5) Connect the red lead of the battery supply cord to negative battery (48 volts dc) and the black lead to ground.

(6) Insert the XY switch to be tested into the test cell. Make sure the lock-springs are securely fastened.

(7) Plug the XY switch jack (connector plug) into the test set receptacle.

b. Operating Test Instructions, General. While operating the test set, observe the XY switch under test for hesitation, skipping, drop-back, or magnets locking in the operated position. The switch under test should step at the rate of 25 to 32 steps per second in the X direction and 32 to 45 steps per second in the Y direction with an even rhythmic sound and action. *The pulse ratio, automatic stepping,* and *speed* test are made in succession after the XY switch has been inserted into the test cell.

96. Pulse Ratio Tests, XY Stepping

The stepping magnets (X magnet and Y magnet assemblies) are pulsed by a source that supplies 12 pulses per second with 32 percent make for low pulse ratio test and 86 percent make for high pulse ratio test. The switch under test is stepped 10 steps in the X direction, then 10 steps in the Y direction. When the switch reaches the tenth step in the Y direction, it restores to normal and the stepping cycle is repeated. During this test, the continuity of the X off-normal, Y off-normal, and release spring assemblies of the switch are tested in the normal and operated positions.

a. Test for Normal Condition of XY Switch with ONOFF Switch Operated to the ON Position. Check for the following conditions on the XY switch test set and the switch under test:

Lamp				Remarks
Panel marking	Color	On	Off	
Y OFF-NORMAL	White	X	_____	Break contacts of X off-normal springs are made.
X OFF-NORMAL	White	X	_____	Break contacts of Y off-normal springs are made.
OVERFLOW	White	X	_____	Break contacts of X–Y overflow springs are made.
RELEASE	White	X	_____	Break contacts of release springs are made.

b. Test for Low Pulse Ratio with LOW-HIGH (PULSING) Switch Operated to LOW Position and ON-OFF Switch Operated to ON Position. Check for the following:

Test step	Lamp				Remarks
	Panel marking	Color	On	Off	
1	----------	----------	------	------	Moves 1 step in X direction; causes X off-normal springs to operate.
	X OFF-NORMAL	White	------	X	Break contacts of X off-normal springs are open.
	X OFF-NORMAL	Red	X	------	Make contacts of X off-normal springs are made.
2	----------	----------	------	------	Steps to tenth X direction step.
3	----------	----------	------	------	Steps to step 1 in Y direction; Y off-normal springs operate.
	Y OFF-NORMAL	White	------	X	Break contacts of Y off-normal springs are open.
	Y OFF-NORMAL	Red	X	------	Make contacts of Y off-normal springs are made.
4	----------	----------	------	------	Steps to tenth Y direction step.
5	----------	----------	------	------	Release magnet assembly operates; release springs are open.
	RELEASE	White	------	X	Break contacts of release springs are open.
	RELEASE	Red	X	------	Make contacts of release springs are made.
6	----------	----------	------	------	Release magnet causes Y switch to return to Y normal and Y off-normal springs restore.
	Y OFF-NORMAL	Red	------	X	Make contacts of Y off-normal springs are made.
	Y OFF-NORMAL	White	X	------	Break contacts of Y off-normal springs are made.
7	----------	----------	------	------	Release magnet causes the XY switch to return to X normal and X off-normal springs restore.
	X OFF-NORMAL	Red	------	X	Make contacts of X off-normal springs are open.
	X OFF-NORMAL	White	X	------	Break contacts of X off-normal springs are made.
8	----------	----------	------	------	Release magnet restores when XY switch moves to X normal and releases the release springs.
	RELEASE	Red	------	X	Make contacts of release springs are open.
	RELEASE	White	X	------	Break contacts of release springs are made.
9	----------	----------	------	------	The cycle, steps 1 through 8, repeat until LOW-HIGH (PULSING) switch is restored to normal position.

c. High Pulse Ratio Test. When making this test, follow the same procedures as described in *b* above, except for operation of LOW-HIGH (PULSING) switch to the HIGH position.

97. Automatic Stepping Test, XY Direction

This test checks the stepping action of the XY switch under test while stepping under the control of the X and Y interrupter assembly contact springs. The switch is stepped 10 steps in the X direction and 10 steps in the Y direction. When the switch reaches the tenth step in the Y direction, it restores to normal and the stepping cycle is repeated. During this test, the continuity of the X off-normal, Y off-normal, and release springs are tested in the normal and operated (off-normal) positions.

a. Preparation. Prepare and check the XY switch under test in accordance with the instructions contained in paragraphs 95 and 96*a*.

b. Test for Automatic Stepping in XY Direction with STEP-SPEED (AUTO STEP) Switch Operated to STEP Position. This test causes the XY switch to start stepping. Check for the following sequential conditions:

Test step	Lamp				Remarks
	Panel marking	Color	On	Off	
1	----------	----------	-----	-----	Moves 10 steps in X direction.
	X OFF-NORMAL	White	-----	X	Break contacts of X off-normal springs are open.
	X OFF-NORMAL	Red	X	-----	Make contacts of X off-normal springs are made.
2	----------	----------	-----	-----	Moves 10 steps in Y direction.
	Y OFF-NORMAL	White	-----	X	Break contacts of Y off-normal springs are open.
	Y OFF-NORMAL	Red	X	-----	Make contacts of Y off-normal springs are made.
3	----------	----------	-----	-----	Release magnet assembly operates.
	RELEASE	White	-----	X	Break contacts of release springs operate.
	RELEASE	Red	X	-----	Make contacts of release springs are made.
4	----------	----------	-----	-----	XY switch restores.
	Y OFF-NORMAL	Red	-----	X	Make contacts of Y off-normal springs are open.
	Y OFF-NORMAL	White	X	-----	Break contacts of Y off-normal springs are made.
	X OFF-NORMAL	Red	-----	X	Make contacts of X off-normal springs are open.
	X OFF-NORMAL	White	X	-----	Break contacts of X off-normal springs are made.
5	----------	----------	-----	-----	Release magnet assembly restores.
	RELEASE	Red	-----	X	Make contacts of release springs are open.
	RELEASE	White	X	-----	Break contacts of release springs are made.
6	----------	----------	-----	-----	XY switch restores to normal position; steps 1 through 5 repeated until STEP-SPEED (AUTO STEP) is returned to normal position.

98. Automatic Stepping, X Direction

The XY switch under test is stepped 11 steps in the X direction. When the switch reaches the eleventh X direction step, it restores to normal and the stepping cycle is repeated. During this test, the continuity of the X off-normal, X–Y overflow, and the release springs assemblies are tested in the normal and operated positions.

a. Preparation. Prepare and check the XY switch under test in accordance with instructions contained in paragraphs 95 and 96*a*.

b. Test for Automatic Stepping in X Direction with Y–XY–X (AUTO STEP) Switch Operated to the X Position and STEP-SPEED (AUTO STEP) Switch Operated to STEP Position. Check for the following sequential conditions:

Test step	Lamp				Remarks
	Panel marking	Color	On	Off	
1	----------	----------	-----	-----	XY switch steps 11 steps in X direction.
	X OFF-NORMAL	White	-----	X	Make contacts of X off-normal springs are open.
	X OFF-NORMAL	Red	X	-----	Make contacts of X off-normal springs are made.
2	OVERFLOW	White	-----	X	Break contacts of X–Y overflow springs are open.
	OVERFLOW	Red	X	-----	Make contacts of X–Y overflow springs are made.
3	----------	----------	-----	-----	Release magnet operates.
	RELEASE	White	-----	X	Break contacts of release springs are open.
	RELEASE	Red	X	-----	Make contacts of release springs are made.
4	----------	----------	-----	-----	XY switch resstores to X normal position.
	X OFF-NORMAL	Red	-----	X	Make contacts of X off-normal springs are open.
	X OFF-NORMAL	White	-----	X	Remains out.
	OVERFLOW	Red	-----	X	Make contacts of X–Y overflow springs are open.
	OVERFLOW	White	X	-----	Break contacts of X–Y overflow springs are made.
5	----------	----------	-----	-----	Release magnet restores.
	RELEASE	Red	-----	X	Make contacts of release springs are open.
	RELEASE	White	X	-----	Break contacts of release springs are made.

Test step	Lamp				Remarks
	Panel marking	Color	On	Off	
6	----------	----------	------	------	XY switch restores to normal position; steps STEP-SPEED (AUTO STEP) switch is restored to normal. Restore the Y–XY–X (AUTO STEP) switch to normal.

99. Automatic Stepping, Y Direction

The XY switch under test is stepped 11 steps in the Y direction. When the switch reaches the 11th Y direction step, it restores to normal and the stepping cycle is repeated. During this test, the continuity of the Y off-normal, X–Y overflow, and release spring assemblies are tested in the normal and operated positions.

a. Preparation. Prepare and check the XY switch under test in accordance with instructions contained in paragraphs 95 and 96*a*.

b. Test for Automatic Stepping in Y Direction With Y–XY–X (AUTO STEP) Switch Operated to the STEP Position. Check for the following sequential conditions:

Test step	Lamp				Remarks
	Panel marking	Color	On	Off	
1	----------	----------	------	------	XY switch steps 11 steps in Y direction.
	Y OFF-NORMAL	White	------	X	Make contacts of Y off-normal springs are open.
	Y OFF-NORMAL	Red	X	------	Make contacts of Y off-normal springs are made.
2	OVERFLOW	White	------	X	Break contacts of X–Y overflow springs are open.
	OVERFLOW	Red	X	------	Make contacts of X–Y overflow springs are made.
3	----------	----------	------	------	Release magnet operates.
	RELEASE	White	------	X	Break contacts of release springs are open.
	RELEASE	Red	X	------	Make contacts of release springs are made.
4	----------	----------	------	------	XY switch restores to Y normal position.
	Y OFF-NORMAL	Red	------	X	Make contacts of Y off-normal springs are open.
	Y OFF-NORMAL	White	------	X	Remains out.
	OVERFLOW	Red	------	X	Make contacts of X–Y overflow springs are open.
	OVERFLOW	White	X	------	Break contacts of X–Y overflow springs are made.
5	----------	----------	------	------	Release magnet restores.
	RELEASE	Red	------	X	Make contacts of release springs are open.
	RELEASE	White	X	------	Break contacts of release springs are made.
6	----------	----------	------	------	XY switch restores to Y normal position and steps 1 through 5 repeat until STEP-SPEED (AUTO STEP) switch is restored to normal position. Restore the Y–XY–X (AUTO STEP) switch to normal.

100. Speed Test, X Direction

The X–Y switch is stepped 11 steps in the X direction under control of the X interrupter assembly contact springs. When the XY switch reaches the 11th step, it remains in that position until the STEP-SPEED switch is restored to normal. Observe the SPEED lamps as the XY switch is stepping and after the XY switch under test reaches the X overflow position.

a. Preparation. Prepare and check the XY switch under test in accordance with instructions contained in paragraphs 95 and 96*a*.

b. Test for X Direction Speed with Y–XY–X (AUTO STEP) Switch Operated to X Position and STEP-SPEED (AUTO STEP) Switch Operated to SPEED Position. Check for the following sequential conditions:

Test step	Lamp				Remarks
	Panel marking	Color	On	Off	
1	----------	----------	------	------	XY switch steps 11 steps in X direction.
	X OFF-NORMAL	White	------	X	Make contacts of X off-normal springs are open.
	X OFF-NORMAL	Red	X	------	Make contacts of X off-normal springs are made.
	OVERFLOW	White	------	X	Break contacts of X–Y overflow springs are open.
	OVERFLOW	Red	X	------	Make contacts of X–Y overflow springs are made.
2	----------	----------	------	------	Observe SPEED lamps while XY switch under test is stepping. Last condition should apply.
	25–32 SPEED	Green	------	X	Stepping speed of XY switch is above 45 steps per second. Readjust switch.
	32–45 SPEED	Green	------	X	Same as above.
	25–32 SPEED	Green	------	------	Lights once and then goes out if stepping speed of XY switch is below 25 steps per second. Readjust switch.
	32–45 SPEED	Green	------	------	Same as above.
	32–45 SPEED	Green	X	------	Stepping speed of XY switch is above 32, but not above 45 steps per second. Readjust switch for X direction only.
	25–32 SPEED	Green	X	------	Stepping speed of XY switch is from 25 to 32 steps per second.
3	----------	----------	------	------	Restore the SPEED-STEP (AUTO STEP) switch to normal; release magnet operates.
	RELEASE	White	------	X	Break contacts of release springs are open.
	RELEASE	Red	X	------	Make contacts of release springs are made.
	25–32 SPEED	Green	------	X	
	32–45 SPEED	Green	------	X	
	OVERFLOW	Red	------	X	Make contacts of X–Y overflow springs are open.
	OVERFLOW	White	X	------	Break contacts of X–Y overflow springs are made.
4	----------	----------	------	------	XY switch restores to X normal position.
	X OFF-NORMAL	Red	------	X	Make contacts of X off-normal springs are open.
	X OFF-NORMAL	White	------	X	Remains out.
5	----------	----------	------	------	Release magnet restores.
	RELEASE	Red	------	X	Make contacts of release springs are open.
	RELEASE	White	X	------	Make contacts of release springs are made.
6	----------	----------	------	------	XY switch restores to X normal position and steps 1 through 5 repeat until Y–XY–X (AUTO STEP) switch is restored to normal.

101. Speed Test, Y Direction

The XY switch under test is stepped 11 steps in the Y direction under control of the Y interrupter assembly contact springs. When the XY switch reaches the 11th step, it remains in that position until the STEP-SPEED (AUTO STEP) switch is restored to normal. Observe the SPEED lamps as the XY switch is stepping and after the XY switch reaches the Y overflow position.

a. Preparation. Prepare and check the XY switch under test in accordance with the instructions contained in paragraphs 95 and 96*a*.

b. Test for Y Direction Speed with Y–XY–X (AUTO STEP) Switch Operated to Y Position and STEP-SPEED (AUTO STEP) Switch Operated to SPEED Position. Check for the following sequential conditions:

Test step	Lamp				Remarks
	Panel marking	Color	On	Off	
1	----------	----------	------	------	XY switch steps 11 steps in Y direction (from X normal position).
	X OFF-NORMAL	White	------	X	Make contacts of Y off-normal springs are open.
	X OFF-NORMAL	Red	X	------	Make contacts of Y off-normal springs are made.
	OVERFLOW	White	------	X	Break contacts of X–Y overflow springs are open.
	OVERFLOW	Red	X	------	Make contacts of X–Y overflow springs are made.
2	----------	----------	------	------	Observe SPEED lamps while XY switch under test is stepping.
	25–32 SPEED	Green	------	X	Stepping of XY switch is above 45 steps per second. Readjust switch.
	32–45 SPEED	Green	------	X	Same as above.
	25–32 SPEED	Green	------	------	Lights once and then goes out if stepping speed of XY switch is below 25 steps per second. Readjust switch.
	32–45 SPEED	Green	------	------	Same as above.
	25–32 SPEED	Green	X	------	Stepping speed of XY switch is from 25 to 32 steps per second. Readjust for Y direction only.
	32–45 SPEED	Green	X	------	Stepping speed of XY switch is above 32, but not above 45 steps per second.
3	----------	----------	------	------	Restore the SPEED-STEP (AUTO STEP) switch to normal; release magnet operates.
	RELEASE	White	------	X	Break contacts of release springs are open.
	RELEASE	Red	X	------	Make contacts of release springs are made.
	25–32 SPEED	Green	------	X	
	32–45 SPEED	Green	------	X	
	OVERFLOW	Red	------	X	Make contacts of X–Y overflow springs are open.
	OVERFLOW	White	X	------	Break contacts of X–Y overflow springs are made.
4	----------	----------	------	------	XY switch restores to Y normal position.
	X OFF-NORMAL	Red	------	X	Make contacts of X off-normal springs are open.
	X OFF-NORMAL	White	------	X	Remains out.
5	----------	----------	------	------	Release magnet restores.
	RELEASE	Red	------	X	Make contacts of release springs are open.
	RELEASE	White	X	------	Make contacts of release springs are made.
6	----------	----------	------	------	XY switch restores to Y normal position and steps 1 through 5 repeat until Y–XY–X (AUTO STEP) switch is restored to normal.

102. XY Switch Test Completed

a. Operate the ON-OFF switch to the OFF position. All white lamps go out.

b. Disconnect the XY switch jack from the test set receptacle.

c. Remove the XY switch under test from the test cell.

d. Disconnect the battery supply cords.

e. Replace the test set cover.

103. X Magnet Holding Battery

This test supplies a low voltage battery (approximately 24 volts dc) to energize the X magnet without overheating the winding of the X magnet coil. This provides the means to energize the X magnet assembly for adjustment.

a. Prepare the test set and XY switch being adjusted in accordance with instructions in paragraphs 95 and 96*a*.

b. Operate the 24V–30–PT–36–PT switch to the 24V position. This energizes the X magnet assembly, but the switch wiper assemblies do not move.

c. Perform the required adjustments (par. 81).

d. Restore the 24V–30–PT–36–PT switch to the 30–PT position after the adjustments.

e. Disconnect the test set and XY switch being adjusted (par. 102).

104. Y Magnet Holding Battery

This test supplies a low voltage battery (approximately 24 volts dc) to the Y magnet coil for adjustment. This provides a means of energizing the Y magnet coil without overheating the winding.

a. Prepare the test set and XY switch being adjusted in accordance with paragraphs 95 and 96*a*.

b. Operate the Y–XY–X (AUTO STEP) switch to the Y position.

c. Operate the 24V–30–PT–36–PT switch to the 24V position. This energizes the Y magnet assembly, but the wiper assemblies do not move.

d. Perform the required adjustments (par. 83).

e. Restore the 24V–30–PT–36–PT switch to the 30–PT position after adjustments are made.

f. Restore the Y–XY–X (AUTO STEP) switch to the XY position following adjustments.

g. Disconnect the test set and XY switch being adjusted (par. 102).

Section VI. ROTARY SWITCH

105. Nomenclature and Function of Assemblies and Parts

To orient the rotary switch, place it in a vertical position with the indicator at the left and interrupter spring assembly to the top and right side. This will orient the rotary switch with respect to front and back, right and left sides, corresponding to its position when mounted to the bay framework.

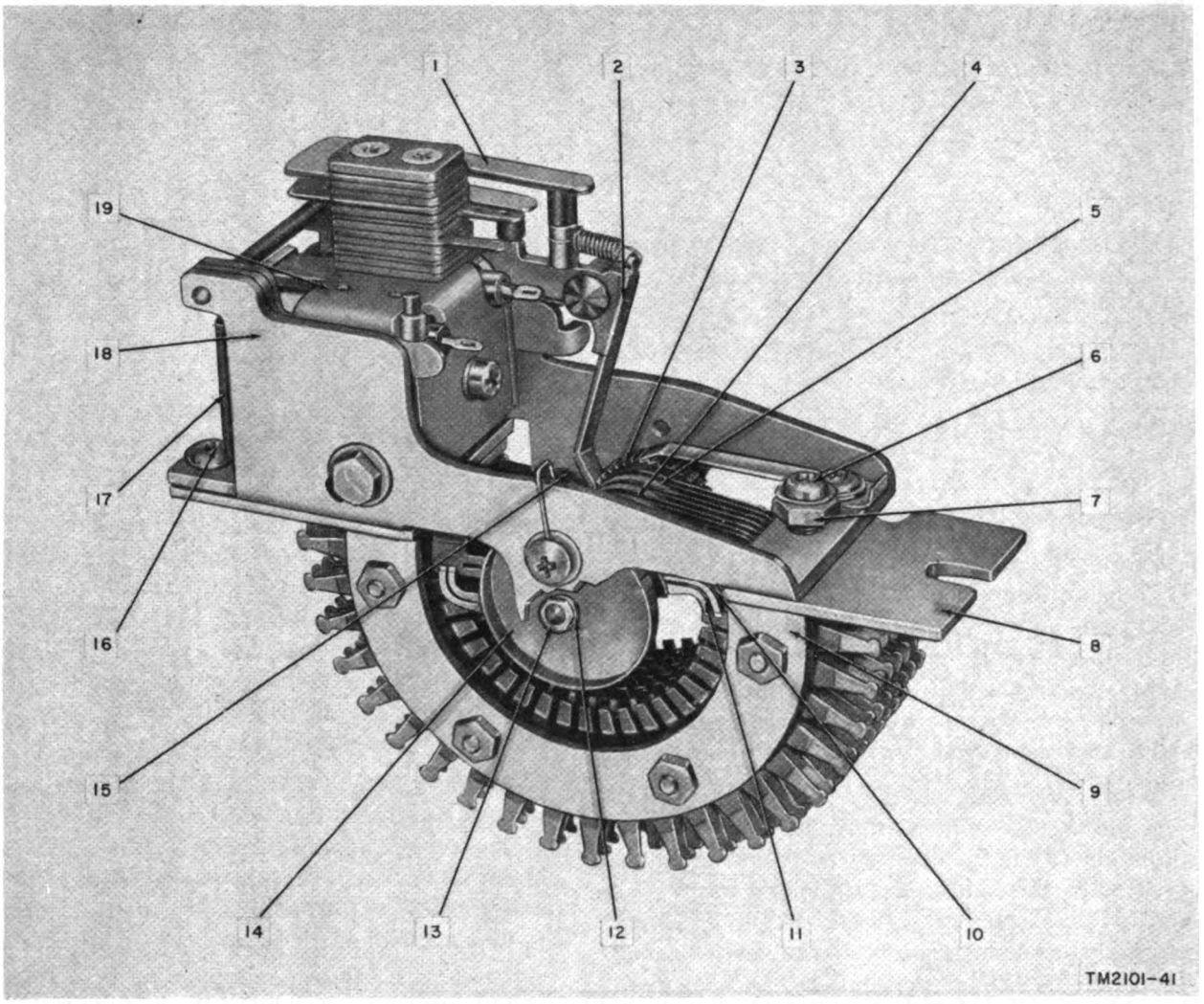
a. Bank Assembly (fig. 41). The bank assembly (9) is fastened to the frame assembly (18) with the bank adjusting lock screw (6) and two bank retaining screws (16). The bank assembly consists of eight banks, each having 21 contacts: 20 bank contacts and 1 brush spring contact. The eight banks are identified as levels A, B, C, D, E, F, G, and H; with level A located on the right side. The contacts in each level are numbered 1 through 20 from top to bottom. The brush spring contact is the first contact in each level. The bank frame (8) is slotted at the top and bottom for mounting the rotary switch to the bay framework.

b. Frame Assembly (fig. 41). The frame assembly (18) is a mounting for the wiper assembly (4), armature assembly (17), and coil frame (19). The frame assembly is positioned with respect to the bank assembly by the bank frame adjusting bushing (7).

c. Wiper Assembly (fig. 41). The wiper assembly (4) is fastened to the frame assembly (18) by the wiper assembly bearing pin and screw (17 and 18, fig. 42). The paired right- and left-hand wiper springs (10 and 11, fig. 41) are positioned on the ratchet gear (3) by the key spacers (12) and insulators (5) and fastened in place, as in the indicator (14), by the wiper assembly locknut (13). The paired wiper springs are stepped in a counterclockwise direction over the 20 bank contacts and 1 brush spring contact in each level through the action of the pawl- and-ratchet mechanism.

d. Pointer (fig. 42). The pointer (3) is fastened to the frame assembly (29) by the pointer screw and washer (1 and 2). The pointer is located over the engraved markings on the indicator (34) and shows the position of the wiper springs in the bank assembly.

e. Armature Assembly and Driving Pawl (fig. 42). The armature assembly (28) is fastened between the ears of the frame assembly (29) by the bearing pin which is fastened to the armature backstop (26). The armature backstop is fastened to the frame assembly by the backstop screw (27). The armature assembly is positioned with respect to the coil frame (9) by the two armature bearing pin washers (10). The driving pawl (19), permanently fastened to the arm of the armature assembly, moves out of engagement with the ratchet gear (33) and drops over the next ratchet gear tooth each time the armature assembly responds to the momentary impulse of current passed through the coil winding (11). In the nonoperate position, the pawl spring (20) holds the driving pawl against the engaged ratchet gear tooth. With the coil energized, the pawl spring holds the driving pawl in the dropover



1 Driving spring (2)
2 Driving pawl
3 Ratchet gear
4 Wiper assembly
5 Insulator (9)
6 Bank adjusting lock screw (8–32 x ⅜ inch)
7 Bank frame adjusting bushing
8 Bank frame
9 Bank assembly
10 Right-hand wiper spring (8)
11 Left-hand wiper spring (8)
12 Key spacer (9)
13 Wiper assembly lock nut
14 Indicator
15 Pawl stop
16 Bank retaining screw (2, 8–32 x 7/16 inch)
17 Armature assembly
18 Frame assembly
19 Coil frame

Figure 41. Rotary switch (left side).

position and places it in a position to achieve the driving action.

f. Pawl Stop (fig. 41). The pawl stop (15) is fastened to the frame assembly (18) by the pawl stop screw and washer (31 and 32, fig. 42). When the armature assembly is operated to the backstop position, the driving pawl (2, fig. 41) moves down onto the radial face of the tooth. This travel is limited by the pawl stop.

g. Detent Spring (fig. 42). The detent spring (14) is fastened to the frame assembly by the detent spring screw and washer (15 and 16). During release (coil assembly deenergized), the detent spring rides over the flank of the ratchet gear tooth and is then engaged by the radial face of the tooth. The ratchet gear is maintained at that position until the coil assembly is again energized.

h. Coil Frame (fig. 42). The coil frame (9) is fastened to the frame assembly by the two coil frame adjust screws and washers (6 and 7) and positioned by the coil frame adjust spacer (8). The coil frame is a mounting surface for the coil assembly (11), interrupter spring assembly (12), armature assembly (28), and backstop support (30).

i. Backstop Support (fig. 42). The backstop support (30) is fastened to the right side of the frame assembly (29) by the coil frame adjust screw and washer (6 and 7). The backstop support positions and supports the armature backstop.

j. Armature Backstop (fig. 42). The armature backstop (26) is fastened to the frame assembly (29) by the backstop screw (27). The backstop support bearing pin fastens the armature assembly between the ears of the frame assembly. The arm of the backstop support limits the travel of the armature assembly. The armature backstop is positioned (adjusted) by the backstop support.

k. Interrupter Spring Assembly (fig. 42). The interrupter spring assembly (12) is fastened to the coil frame (9) by two interrupter spring assembly screws (13). When the coil assembly is energized, one of the two armature bushings (21) moves against the two driving springs (25) and prepares the assembly for the release operation. The other armature bushing (22) mechanically breaks the contacts of the armature and make springs (23 and 24). When the armature and make springs break, the circuit to the coil assembly is open and the armature assembly releases. This release action is achieved through the action of the two driving springs which return the armature assembly to its backstop position. During release, the make and armature spring contacts are again made and the circuit to the coil assembly is reestablished.

l. Coil Assembly (fig. 42). The coil assembly (11) is fastened to the coil frame (9) by the coil assembly screw and lockwasher (4 and 5). When the coil assembly is energized, the armature assembly (28) is attracted to the coil core.

106. Operation

The rotary switch is a nonnumerical switch used as a part of the allotter circuit. For a description of the circuit function of the rotary switch, refer to TM 11–2116. The mechanical operations necessary to step the rotary switch are described in *a* through *c* below.

a. Seizure. When an external circuit is completed through contacts 1 and 2 of the interrupter spring assembly and through the winding of the coil, the armature is attracted to the coil core of the magnet (coil assembly).

b. Off-Normal. When the armature is attracted to the coil core, the armature bushings are driven upward against the driving and armature springs.

(1) The driving pawl which pivots on the arm of the armature assembly is driven upward over the flank of the ratchet gear tooth, falling over the radial edge of the tooth into the root.

(2) At the rise, the one armature bushing tensions the two driving springs (working together) and the other bushing breaks the armature and make spring contacts.

(3) When the contacts break, the circuit to the coil assembly is opened and the armature assembly releases.

(4) During release, the driving pawl moves against the radial face of the tooth and rotates the ratchet gear and associated wiper assembly one step forward in a clockwise direction. The bushing moves downward and the armature and make springs, close the circuit to the coil assembly.

c. Stepping. For each pulse of current passed through the coil, the rotary switch takes one step. This action steps the paired wiper springs of the wiper onto the next row of eight bank contacts in levels A through H.

107. Removal and Replacement of Complete Rotary Switch

a. Removal. Before removing the complete rotary switch, busy out the allotter circuit (par. 111*a*).

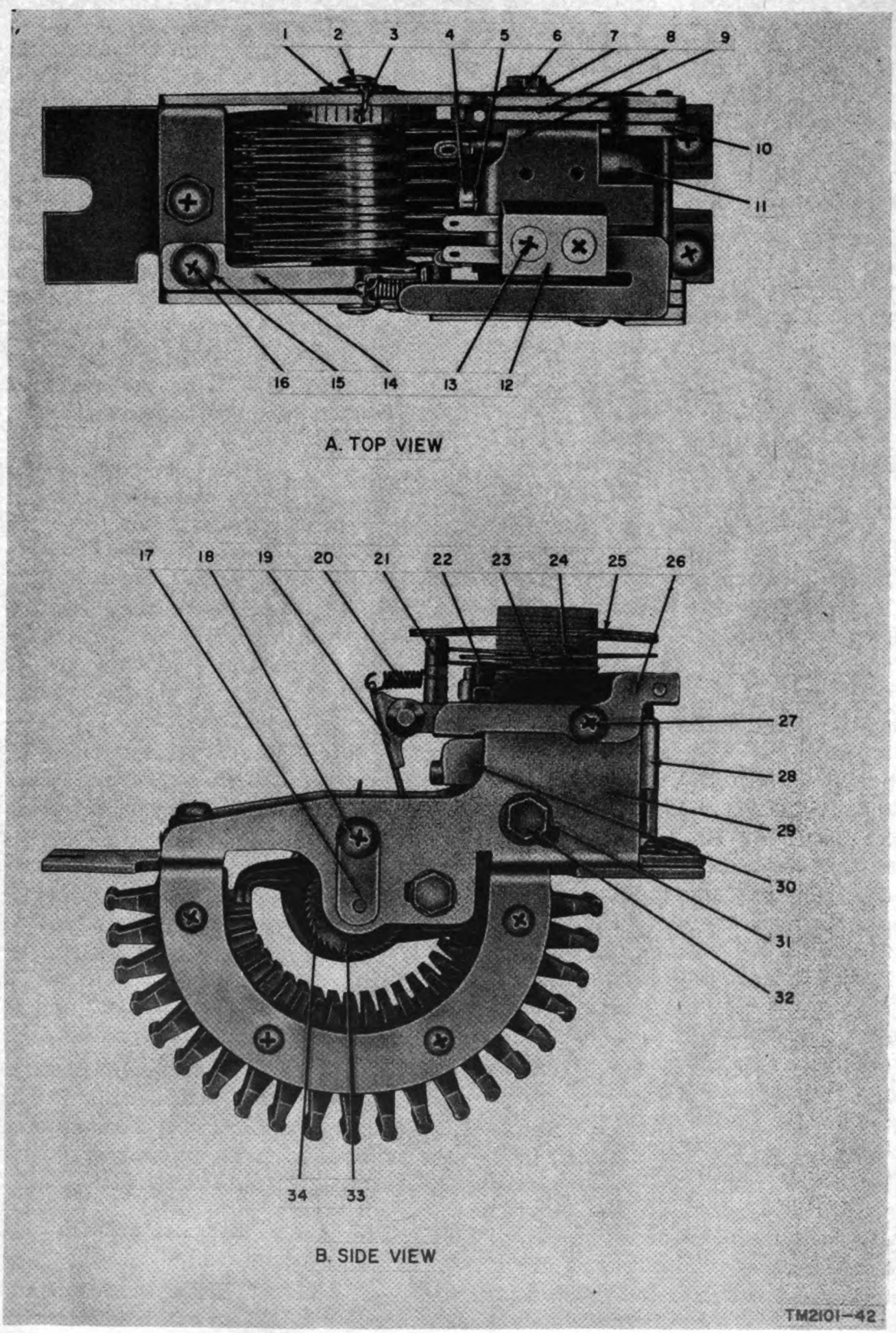


Figure 42. Rotary switch, top and right side.

1 Pointer washer
2 Pointer screw (6–32 x ⅛ inch)
3 Pointer
4 Coil assembly screw (8–32 x ⅜ inch)
5 Coil assembly lock washer
6 Coil frame adjust screw (2)
7 Coil frame adjust washer (2)
8 Coil frame adjust spacer
9 Coil frame
10 Armature bearing pin washer (2)
11 Coil assembly
12 Interrupter spring assembly
13 Interrupter spring assembly screw (2, 6–32 x ½ inch)
14 Detent spring
15 Detent spring washer
16 Detent spring screw (6–32 x ⅛ inch)
17 Wiper assembly bearing pin
18 Wiper assembly bearing pin screw (6–32 x ⅛ inch)
19 Driving pawl
20 Pawl spring
21 Armature bushing
22 Armature bushing
23 Make spring
24 Armature spring
25 Driving spring (2)
26 Armature backstop
27 Backstop screw (6–32 x ⅛ inch)
28 Armature assembly
29 Frame assembly
30 Backstop support
31 Pawl stop washer
32 Pawl stop screw
33 Ratchet gear
34 Indicator

Figure 42—Continued.

(1) Remove the top and bottom mounting bolts that secure the rotary switch to the bay framework.

(2) Unsolder all wires to the brush spring and bank contacts, tagging each wire as it is removed.

b. Replacement. After performing the replacement of parts, readjustment, and final bench testing, replace the rotary switch.

(1) Solder the designated wires (tagged) to the proper brush spring and bank contacts.

(2) Place the rotary switch over the mounting holes, with the indicator on the left side and the interrupter spring assembly in the upper right corner.

(3) Secure the rotary switch with the top and bottom mounting bolts.

(4) Recheck the alinement of the wiper assembly with the bank assembly (par. 114*a*).

(5) Perform the operational final tests (par. 121*b*).

(6) Return the switch to service.

108. Disassembly (fig. 43)

a. Bank Assembly.

(1) Manually operate the armature assembly (26) the required number of times needed to move the wiper assembly (8) to position 20 on the indicator (11).

(2) Use a Phillips screwdriver to remove the two bank retaining screws (1) that fasten the top of the frame assembly (4) to the bank assembly (5).

(3) Use a Phillips screwdriver to remove the bank adjusting lock screw (2) and use an end wrench to remove the bank frame adjusting bushing (3).

(4) Disengage the bank assembly (5) by carefully removing the brush spring contacts from their corresponding wipers. Do not twist or force the bank assembly during disengagement.

Note. The bank assembly is replaceable as an assembly only. Do not attempt to disassemble.

b. Wiper Assembly. The wiper assembly is not normally disassembled. When disassembly is necessary, follow the procedures outlined below.

(1) Use a Phillips screwdriver to remove the wiper assembly bearing pin screw (6).

(2) Extract the wiper assembly bearing pin (7).

(3) Remove the wiper assembly (8) from the frame assembly (4) by pulling it out through the back, away from the engaging driving pawl.

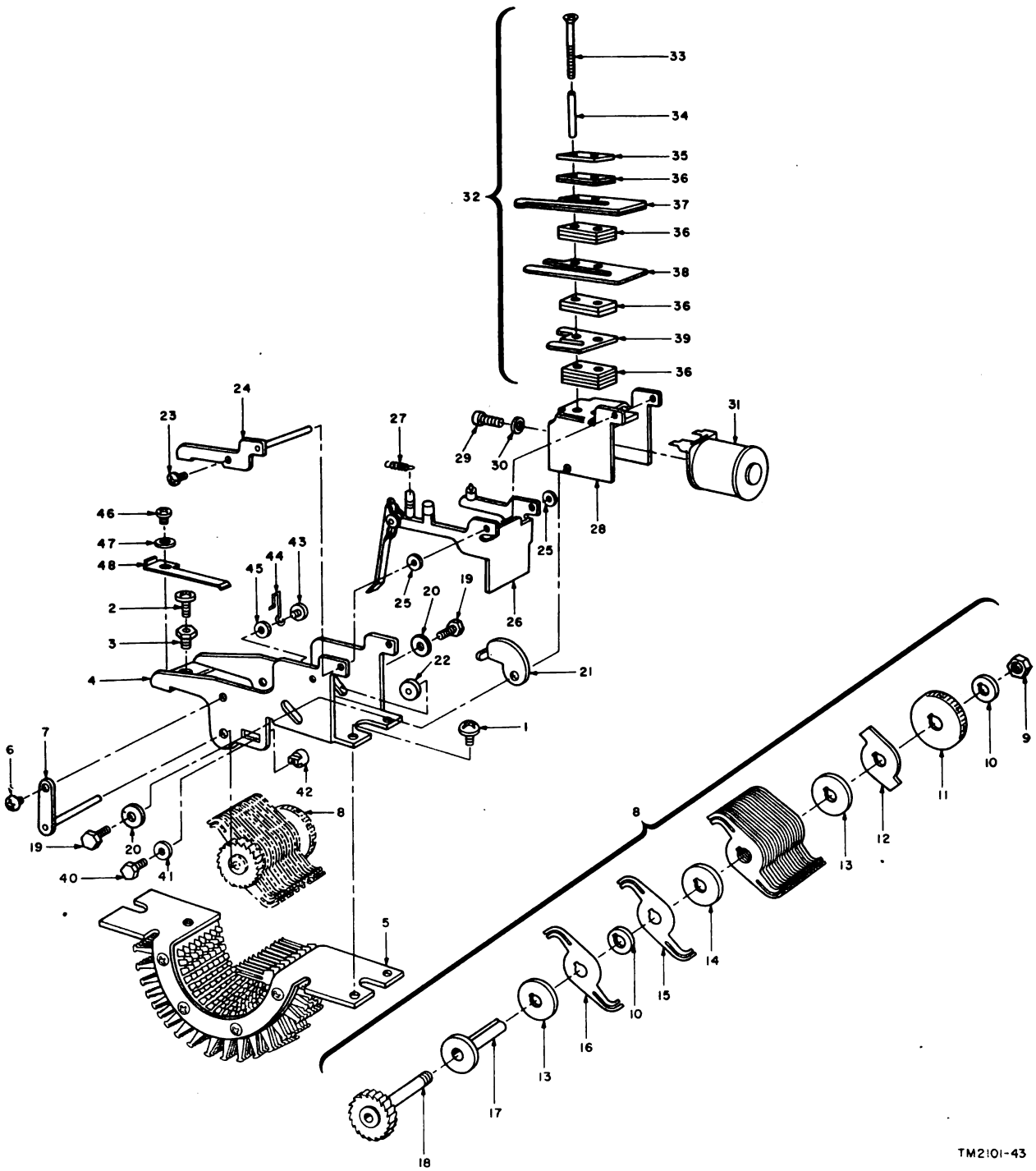


Figure 43. Rotary switch, exploded view.

1 Bank retaining screw (2, 8–32 x 7/8 inch)
2 Bank adjusting lock screw (8–32 x 3/8 inch)
3 Bank frame adjusting bushing
4 Frame assembly
5 Bank assembly
6 Wiper assembly bearing pin screw (6–32 x 1/8 inch)
7 Wiper assembly bearing pin
8 Wiper assembly
9 Wiper assembly lock nut
10 Key spacer (9)
11 Indicator
12 Key insulator
13 Insulator (2)
14 Insulator (7)
15 Left-hand wiper spring (8)
16 Right-hand wiper spring (8)
17 Ratchet gear bushing
18 Ratchet gear
19 Coil frame adjust screw (2)
20 Coil frame adjust washer (2)
21 Backstop support
22 Coil frame adjust spacer
23 Backstop screw (6–32 x 1/8 inch)
24 Armature backstop
25 Armature bearing pin washer (2)
26 Armature assembly
27 Pawl spring
28 Coil frame
29 Coil assembly screw (8–32 x 3/8 inch)
30 Coil assembly lock washer
31 Coil assembly
32 Interrupter spring assembly
33 Interrupter spring assembly screw (2, 6–32 x 1/2 inch)
34 Sleeve
35 Pressure plate
36 Spacer (4 groups)
37 Driving spring (2)
38 Armature spring
39 Make spring
40 Pawl stop screw
41 Pawl stop washer
42 Pawl stop
43 Pointer screw (6–32 x 1/8 inch)
44 Pointer
45 Pointer washer
46 Detent spring screw (6–32 x 1/8 inch)
47 Detent spring washer
48 Detent spring

Figure 43—Continued.

(4) Remove the wiper assembly locknut (9).

(5) Lift the key spacers (10), indicator (11), insulators 12, 13 and 14), and right- and left-hand wiper springs (15 and 16) free of the ratchet gear bushing (17).

(6) Free the ratchet gear bushing from the shaft of the ratchet gear (18).

c. Armature Assembly.

(1) Use a 5/16-inch socket wrench to remove the two coil-frame adjust screws and washers (19 and 20), freeing the backstop support (21) and coil frame adjust spacer (22).

(2) Use Phillips screwdriver to remove the backstop screw (23).

(3) Extract the armature backstop (24) and free the two armature bearing pin washers (25).

(4) Lift the armature assembly (26) free of the frame assembly (4). This will release the coil frame (29) which should be set aside.

(5) Use long-nosed pliers to free the pawl spring (27) from the armature bushing and driving pawl mounting hole.

d. Coil Assembly.

(1) Remove the coil assembly screw and lockwasher (29 and 30).

(2) Extract the coil assembly (31) from the coil frame (28).

e. Interrupter Spring Assembly.

(1) Remove the interrupter spring assembly (32) by removing the two interrupter spring assembly screws and sleeve (33 and 34) that secure the assembly to the coil frame (28).

(2) Remove the pressure plate (35) and free the spacers (36), two driving springs (37) armature, and the make springs (38 and 39).

f. Pawl Stop, Pointer, and Detent Spring.

(1) Use 5/16-inch socket wrench to remove the pawl stop screw (40), and then free the pawl stop washer (41) and pawl stop (42) from the frame assembly (4).

(2) Use a Phillips screwdriver to remove the pointer screw (43), and then free

the pointer (44) and pointer washer (45) from the frame assembly.

(3) Use a Phillips screwdriver to remove the detent spring screw (46), and then free the detent spring washer (47) and detent spring (48) from the frame assembly.

109. Reassembly (fig. 43)

The reassembly instructions provide for the approximate adjustment of all parts and assemblies. Specific instructions for adjustment are listed below in paragarphs 110 through 120.

Caution: **Do not attempt to operate the rotary switch until final adjustments and testing are completed.**

a. Wiper Assembly.

(1) Slip the ratchet gear bushing (17) over the shaft of the ratchet gear (18).

(2) Place the insulator (13) over the ratchet gear bushing (17), and then the righthand wiper spring (16), followed by the key spacer (10) and the left-hand wiper spring (15). Slip on the large insulator (14), the next right-hand wiper spring (16) and key spacer (10), followed by a left-hand wiper spring (15). Continue this procedure until the nine key spacers and eight right- and left-hand wiper springs have been placed on the bushing.

(3) Place the key insulator (12) and the small insulators (13) on the ratchet gear bushing (17).

(4) Place the indicator (11) and key spacer (10) on the ratchet gear bushing (17) and fasten the assembled parts with the wiper assembly locknut (9). Be sure to locate the indicator so that the open face is on the left side with the straightedge of the wipers on a line with position 10 (engraved on the face of the indicator).

(5) Place the wiper assembly (8) between the mounting holes on the frame assembly (4).

(6) Insert the wiper assembly bearing pin (7) through the right-side mounting hole of the frame assembly, through the shaft of the ratchet gear (18), and through the left-side mounting hole.

(7) Fasten the wiper assembly bearing pin (7) to the frame assembly with the wiper assembly bearing pin screw (6).

(8) Position the pointer (44) over step 18 of the indicator and fasten to the frame assembly with the pointer screw and washer (43 and 45).

b. Bank Assembly.

(1) Position the wiper assembly (8) on step 18.

(2) Position the bank assembly (5) with the two mounting holes at the top.

(3) Elevate the top of the frame assembly (4) slightly, slipping the bottom paired wiper springs over their corresponding eight bank contacts.

(4) Slide the frame assembly slightly to the left, permitting the lower half of the brush spring contacts to fall into place against the inside right face of the wiper springs.

(5) Slide the frame assembly right, permitting the upper half of the brush spring contacts to fall into place against the inside left face of the wiper springs. If necessary, use long-nosed pliers to position the brush spring contacts. Do not bend the contacts.

(6) Secure the top of the bank assembly to the frame assembly with the two bank retaining screws (1).

(7) Use an end wrench to screw the bank frame adjusting bushing (3) into the bottom mounting hole of the frame assembly.

(8) Insert the bank adjusting lock screw (2) into the bank frame adjusting bushing (3) and screw it through the bank frame adjust bushing (3) into the bottom mounting hole of the bank assembly; use a Phillips screwdriver.

(9) Use the end wrench to adjust the bank frame adjusting bushing. The adjusted wiper spring should ride on the center ⅓ of their respective bank contacts.

(10) Tighten the bank adjust lock screw with a Phillips screwdriver to move it down onto the flat head of the bank frame adjust bushing.

c. Coil Frame.

(1) Insert the coil frame (28) between the right and left sides of the frame assembly (4), with the ears faced toward the top.

(2) Insert the backstop support (21) between the right side of the frame assembly (4) and coil frame (28), lining it up with the slotted mounting hole. Secure the backstop support with the coil frame adjust screw and washer (19 and 20); use 5/16 inch socket wrench.

(3) Insert the coil-frame adjust spacer (22) between the left side of the frame assembly and coil frame, lining it up with the slotted mounting hole and secure it with the coil-frame adjust screw and washer (19 and 20); use a 5/16-inch socket wrench.

d. Coil Assembly.

(1) Face the coil assembly (31) in a vertical position, with the two terminations faced downward and to the top of the frame. Slide the coil assembly into the coil frame (28) from the opening at the top.

(2) Secure the coil assembly (31) to the coil frame with the coil assembly screw and lockwasher (29 and 30).

e. Armature Assembly.

(1) Use the 5/16-inch socket wrench to loosen the two coil-frame adjust screws (19).

(2) Face the armature assembly (26) in a vertical position (with the driving pawl on the right) and slip the assembly between the sides of the coil frame (28) and frame assembly (4), lining up the mounting holes in the three ears on each side.

(3) Insert the one armature bearing pin washer (25) between each of the two ears of the frame and armature assemblies.

(4) Insert the armature backstop (24) through the mounting holes in the ears, also through the armature bearing pin washers (25); position the flat edge of the backstop under the arm of the armature assembly (26). Fasten the armature backstop to the frame assembly (4) with the backstop screw (23).

(5) Rotate the assembly downward, positioning the driving pawl so that it engages the teeth of the ratchet gear (18). Finger tighten the two coil-frame adjust screws (19) slightly.

(6) Rotate the backstop support (21) upward until it is flush with the bottom edge of the armature backstop (24).

(7) Recheck the engagement of the driving pawl with the ratchet gear teeth. Tighten the two coil-frame adjust screws (19).

(8) Use long-nosed pliers to replace the pawl spring (27) between the mounting hole in the driving pawl and the armature bushing.

(9) Secure the pawl stop (42) to the frame assembly (4) with the pawl stop screw and washer (40 and 41); tighten the screw slightly.

(10) Slide the pawl stop (42) along the slot until it is flush with the back of the driving pawl. Tighten the pawl stop screw (40).

(11) Position the detent spring (48) so that the front edge is flush with the teeth of the ratchet gear (18) and the back edge (turned-up) approximately flush with the bottom of the frame assembly (4). Fasten the detent spring with the detent spring screw and washer (46 and 47).

f. Interrupter Spring Assembly.

(1) Invert the two interrupter spring assembly screws (33) and slip on the sleeves (34) and the pressure plate (35), first spacer (3/32-inch thick), two driving springs (37), second spacer (1/8 inch thick), armature spring (38), third spacer (5/64 inch thick), make spring (39), and fourth spacer (15/64 inch thick).

(2) Turn the assembled parts over and position them over the mounting holes on the coil frame (28). Fasten the assembled parts to the coil frame with the two interrupter spring assembly screws (33).

(3) Check to make sure that the make and armature springs (38 and 39) are made and the driving springs (37) are riding on the armature bushing. Operate the armature assembly by hand. The armature and make springs should break, and the driving springs should be tensioned by the rise of the armature bushing.

110. Adjustments, General

The rotary switch should be inspected for signs of worn or damaged parts before proceeding with adjustments. If required, the switch should first be cleaned (par. 194). Where an adjustment affects an associated part or assembly, both should be checked for proper adjustment. After adjustments are completed, perform the final testing (bench service and in service (operational)) of the rotary switch.

111. Preparation for Adjustment

a. Removal from Service.

(1) Locate the allotter circuit plate associated with the A or B rotary switch marked for adjustment.

(2) Operate the busy and reset switch (B & R) on the allotter circuit plate by rotating it 90°. The transfer lamp (white) will light.

b. Removal from Equipment.

(1) Remove the rotary switch from the framework by removing the top and bottom mounting screws.

(2) Pull the rotary switch away from the bay framework.

Note. Sufficient slack has been provided in the cable harness so that the rotary switch may be withdrawn a few inches from the frame. Complete removal will necessitate unsoldering all connections to the bank assembly terminals.

c. Replacement.

(1) Replace the rotary switch by positioning it over the mounting holes in the framework, with the indicator on the left side.

(2) Fasten the top and bottom mounting screws.

(3) Recheck the alinement of the wiper springs on the bank contacts (par. 113*a*).

(4) Resolder all connections; refer to the allotter wiring diagram in TM 11–2116.

112. Adjustment of Armature Assembly (fig. 44)

a. Checks.

(1) Check to see that the armature does not touch the coil frame or frame assembly.

(2) Check to see that the armature strikes the coil frame heelpiece at both ends simultaneously and has a side play between .003 inch and .025 inch.

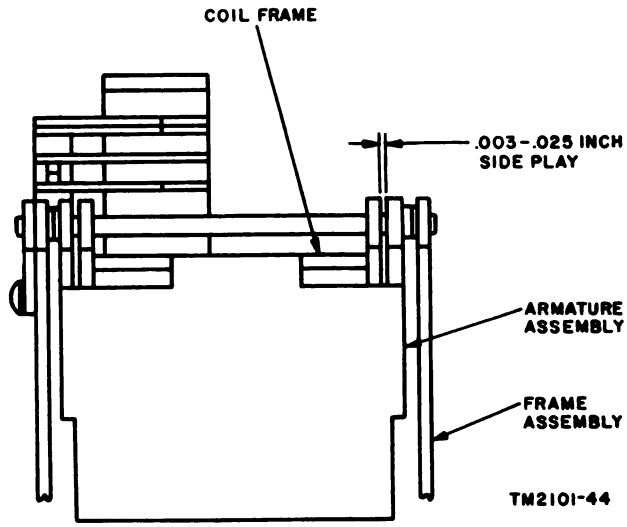


Figure 44. Armature assembly adjustment.

b. Adjustment Procedures.

(1) Insert a screwdriver between the ears of the frame assembly and coil frame to adjust for proper sideplay.

(2) Insert a screwdriver between the armature and the coil frame to adjust the armature strike. Exert only enough pressure necessary to make the specified adjustment.

Caution: **Do not strike the coil assembly with the screwdriver.**

113. Adjustment of Wiper Assembly (fig. 45)

a. Checks.

(1) Check to see that the wiper assembly

sideplay is between .005 inch and .025 inch.

(2) Check to see that the wiper assembly turns freely on its bearing, with the wiper spring tips adjusted so they aline with the bank contacts and brush spring contacts with a maximum of .025 inch side movement as the paired wipers enter and leave the bank.

(3) See that the paired wipers have a minimum of .005-inch clearance between the sides of the wiper springs and their associated brush spring contacts.

(4) Check to see that the tension between the brush spring contact tips and the wiper spring hub is between 35 and 60 grams of pressure.

(5) Be sure that the wiper spring tension is equally divided between the paired tips and is between 15 and 40 grams.

(6) Check all wiper and brush spring contacts for any sharp bends or kinks.

b. Adjustment Procedures.

(1) Place a screwdriver under the pawl stop and rest it against the Phillips-head screw for leverage to adjust the wiper sideplay.

(2) Loosen the bank adjust lock screw and use the end wrench to move the bank frame adjust bushing in or out to aline the wiper spring tips with the bank contacts. Retighten the bank adjust lock screw.

(3) Use a spring adjuster tool to tension the contact springs.

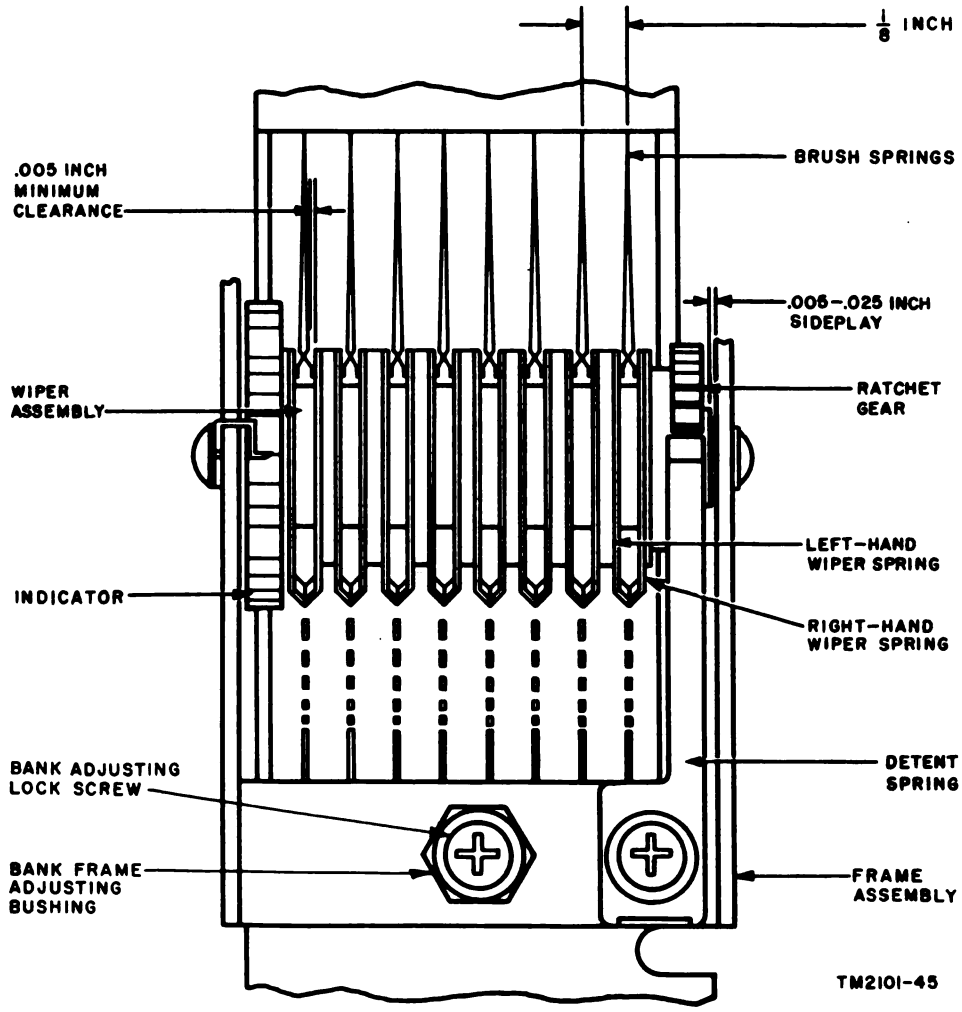


Figure 45. Wiper and bank assembly adjustments.

114. Adjustment of Bank Assembly (fig. 45)

a. Checks.

(1) Check to see that the bank assembly frame is square, with the mounting face perpendicular to the bank levels.

(2) Check the brush springs to see that they are parallel to each other and separated by one-eighth of an inch.

(3) Be sure that the brush spring contacts are in line with their bank contacts at every level.

b. Adjustment Procedures.

(1) Use a spring adjuster tool to aline the brush springs with their respective bank contacts.

(2) Use the end wrench to move the bank frame adjust bushing in or out to aline the brush spring and wiper contacts. If the bank frame is not square or proper separation cannot be obtained, replace the assembly.

115. Adjustment of Pawl Stop (fig. 41)

a. Checks.

(1) Check the tips of the wiper springs to see that they rest on the center one-third area of the bank contacts (fig. 46). During operation, the wipers should leave one contact before touching the next, and leave the last bank contact before the corresponding first wiper tips leave the brush spring contacts.

(2) See that the trailing edges of the wiper tips are in line and parallel with the front edge of the bank contacts on which they rest.

b. Adjustment Procedures.

(1) Adjust the position of the wiper contact in accordance with the instruction contained in paragraph 113*b*(2).

(2) Loosen the pawl stop screw and reposition the pawl stop (15, fig. 41) so that it is adjacent and flush with the face of the driving pawl.

(3) Tighten the pawl stop screw after adment.

(4) Be sure that there is a perceptible clearance between the ratchet gear and the pawl stop.

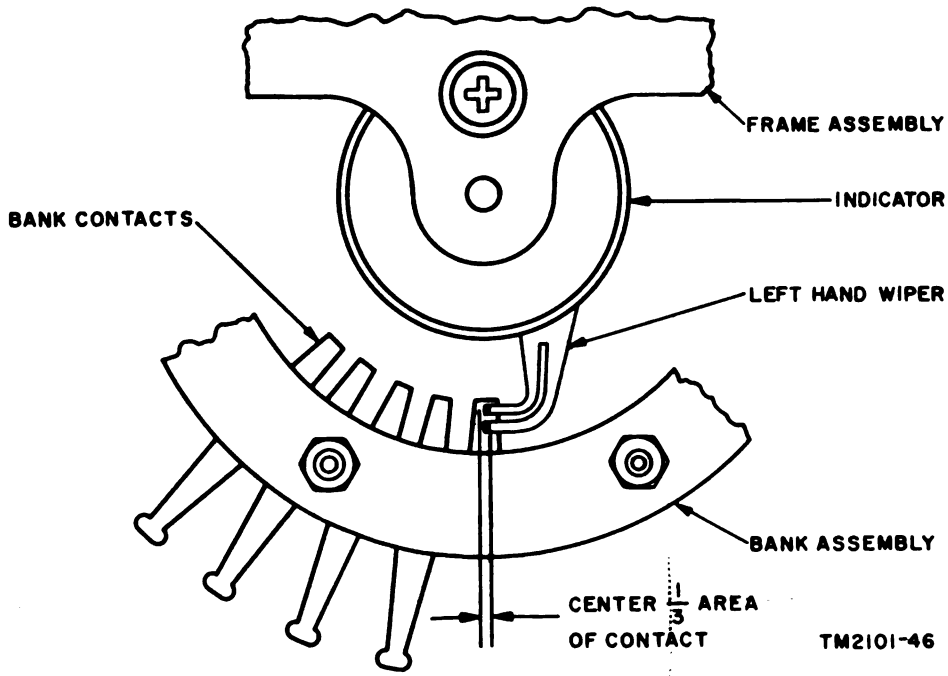


Figure 46. Wiper spring adjustments.

116. Adjustment of Detent Spring (fig. 47)

a. Checks.

(1) See that the detent spring has a tension of from 75 to 125 grams of pressure against the engaged ratchet gear tooth when measured at the tip.

(2) See that the tip is parallel to the root of the ratchet tooth, clearing each tooth by a distance not to exceed .004 inch. This clearance may be checked by rotating the wiper assembly backward and checking the position of the wiper tips on the bank contacts; the tips should be on the center of the back 1/3 of the contact.

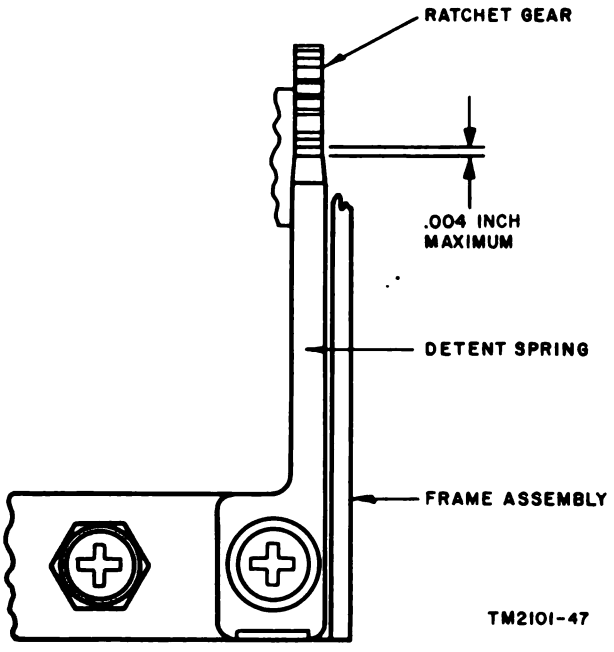


Figure 47. Detent spring adjustments.

b. Adjustment Procedures.

(1) Loosen the detent spring screw and move the part forward or backward to reposition.

(2) Retighten the screw after adjustment.

117. Adjustment of Armature Backstop and Support (fig. 42)

a. Checks.

(1) Be sure that the armature backstop and support is positioned so that the extension arm of the armature assembly rests on the backstop with the tip of the driving pawl flush against the pawl stop.

(2) See that the driving pawl rotates the wiper assembly one step counterclockwise.

b. Adjustment Procedures.

(1) Loosen the backstop screw with a screwdriver and move back or forward to reposition the armature backstop.

(2) Loosen the two coil-frame adjusting screws and move forward or backward to reposition the backstop support.

(3) Retighten all screws after adjustment.

118. Adjustment of Driving Pawl (fig. 48)

a. Checks.

(1) Check to see that the driving pawl is free to move without binding and is positioned so that it engages ratchet teeth squarely without touching the frame during operation.

(2) Be sure that the driving pawl meets the checks listed below.

(*a*) Manually operate the armature to the closed (operated) position with a .002-inch feeler gage placed between the armature and the coil frame. See that the driving pawl rises and engages the next ratchet tooth with no perceptible binding at its tip.

(*b*) Hand operate the armature to the operated position with a .006-inch feeler gage between the armature and coil frame. See that the pawl does not rise and engage the next ratchet tooth.

b. Adjustment Procedures.

(1) Loosen the two coil-frame adjusting screw and reposition the coil frame.

(2) Loosen the pawl stop screw and readjust the position of the pawl stop.

119. Adjustment of Interrupter Spring Assembly (fig. 48)

a. Checks.

(1) Check to see that the armature spring

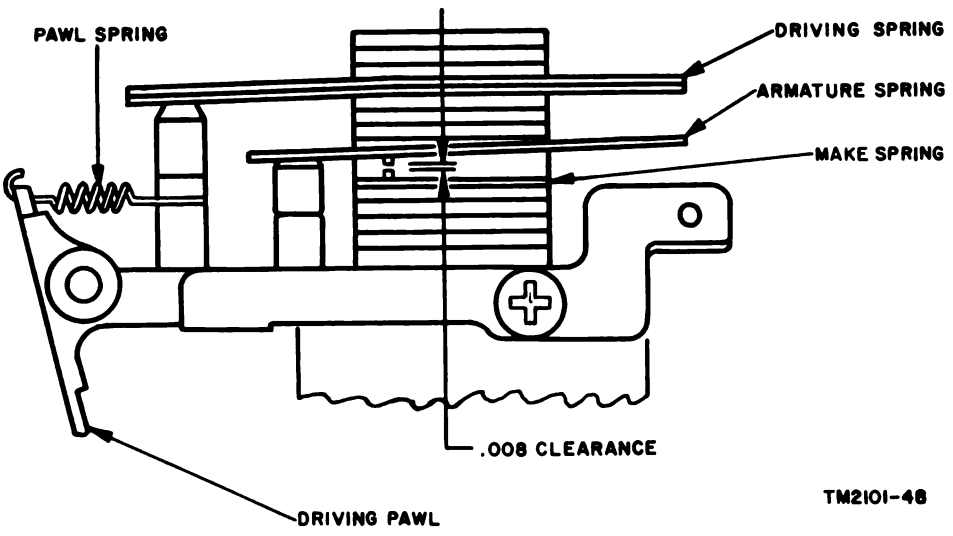


Figure 48. Driving pawl adjustments.

and make spring are tensioned from 250 to 400 grams when measured at a position just above the armature bushing.

(2) Check to see that the driving spring rests against its associated armature bushing with a tension of from 500 to 900 grams pressure. In the operated (break) position, the contact separation should be .008 inch.

b. Adjustments.

(1) Use duck-billed pliers and apply the needed pressure where the spring leaves the pileup to adjust the spring tension.

(2) Form the spring at the contact end to adjust for the proper contact separation.

Caution: **The Phillips-head screws that secure the interrupter spring pileup to the coil bracket should not be loosened or tightened.**

120. Adjustment of Indicator and Pointer (fig. 49)

a. Checks.

(1) Check to see that the wiper tips are on the first bank contacts, and that the indicator and pointer indicate position one.

(2) See that the distance between the pointer and the indicator is $\frac{1}{32}$ inch by visual inspection.

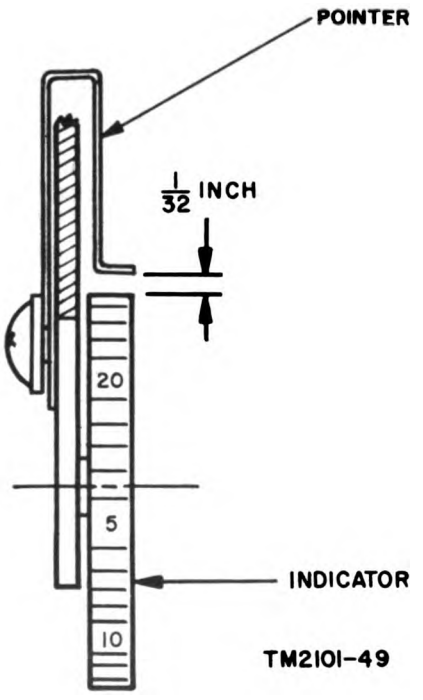


Figure 49. Indicator and pointer adjustment.

b. Adjustments.

(1) Use a Phillips screwdriver to loosen the pointer screw.

(2) Reposition the pointer up or down as required.

(3) Retighten the screw slightly.

(4) Loosen the locknut on the inside slightly, and reposition the indicator; be careful not to disturb the position of the wiper assembly.

(5) Retighten the locknut and check the position of the wiper assembly wipers.

121. Final Testing

Final testing of the rotary switch is divided into two procedures: bench service and operational final testing.

a. Bench Service Testing. To final test the rotary switch at the bench position, follow the procedure listed below:

(1) Connect the rotary switch in accordance with figure 50.
  (*a*) Connect negative battery (BA) to one side of the momentary push-to-make switch (S1).
  (*b*) Connect the other side of BA to ground.
  (*c*) Connect the other side of S1 to terminal C of RX and to terminal 21 (brush spring contact) of the rotary switch (S2).
  (*d*) Connect terminal A of RX to terminal 1 of the interrupter springs (S3).
  (*e*) Connect a 200 ohm resistor in series with a 1 μf capacitor across terminals 1 and 2 of S3.
  (*f*) Connect terminal 2 of S3 to ground.
  (*g*) Connect terminal 1 of S2 to one side of the peg count meter.
  (*h*) Connect the other side of the peg count meter to ground.
(2) Check for smooth operation of the rotary switch, with the drive spring tension on the maximum side.
(3) Check to see that all wipers step to each bank contact.
(4) Check the continuity by placing a buzzer across the wiper and corresponding eight bank contacts. The buzzer should sound in each level.

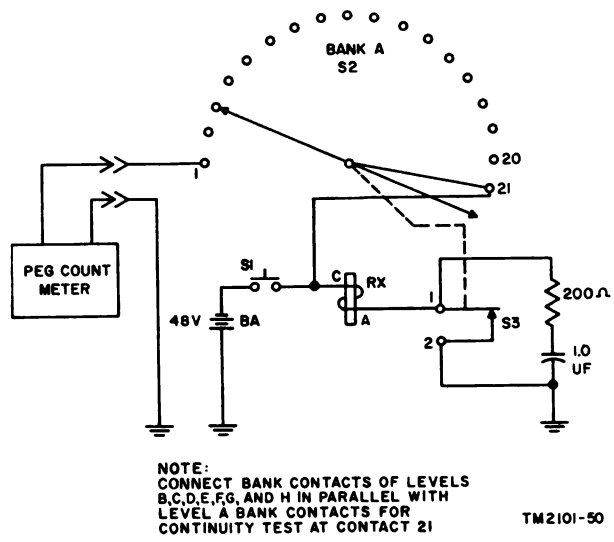


Figure 50. Test setup, rotary switch.

(5) Hold switch S1 closed for one minute.
(6) Multiply the pc meter reading by 20 to determine the stepping speed of the rotary switch. The speed should be 40 to 60 steps per second. If the speed is outside the limits increase the drive spring tension to decrease the stepping speed or decrease the drive spring tension to increase the stepping speed.

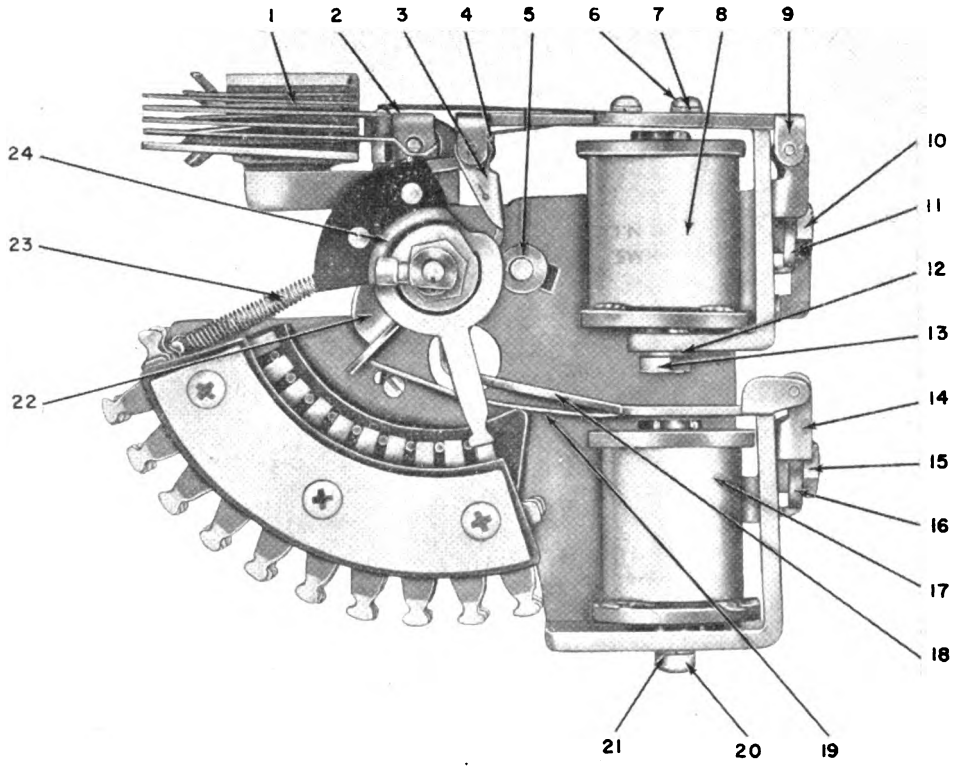
b. Operational Testing. Operational testing is accomplished by routining the allotter circuit plate associated with the rotary switch being checked. During routining, the XY switch associated with each linefinder is stepped 10 steps in the X direction and then stepped to the Y overflow position (Y–11). At Y–11 the linefinder is automatically released, and the allotter steps to the next successive idle linefinder circuit through the switching action of the rotary switch. This testing procedure continues until the test switch (TST) of the allotter is restored to normal. For a description of operational routine testing, refer to TM 11–2120.

Section VII. MINOR SWITCH

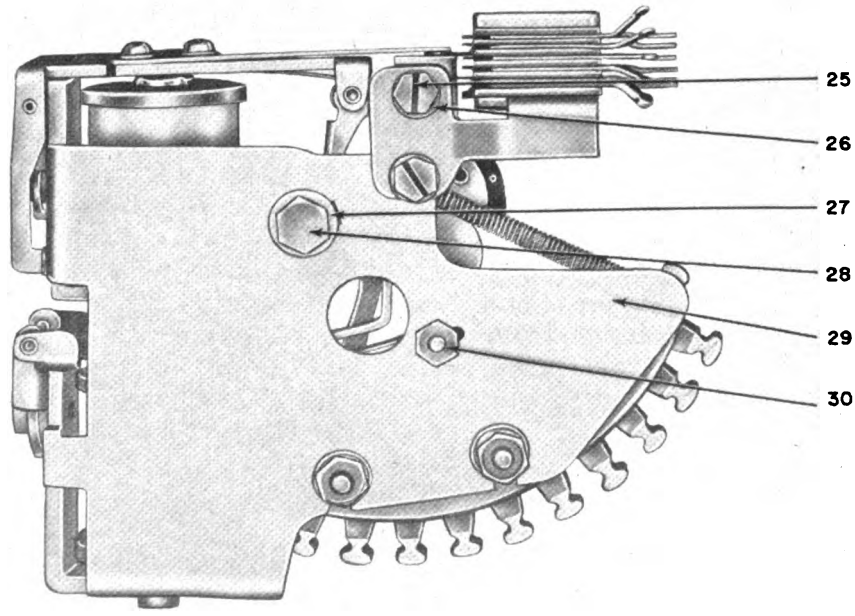
122. Nomenclature and Function of Assemblies and Parts (fig. 51)

To orient the minor switch, position the component so that the rotary magnet is at the upper right and the bank assembly at the lower left. This will orient the minor switch with reference to front and rear, right and left sides.

a. Mounting Plate. The mounting plate (29) is a mounting surface for the assemblies and parts of the minor switch. The mounting plate is made of heavy gage steel.



A. TOP VIEW



B. BOTTOM VIEW

TM2101-51

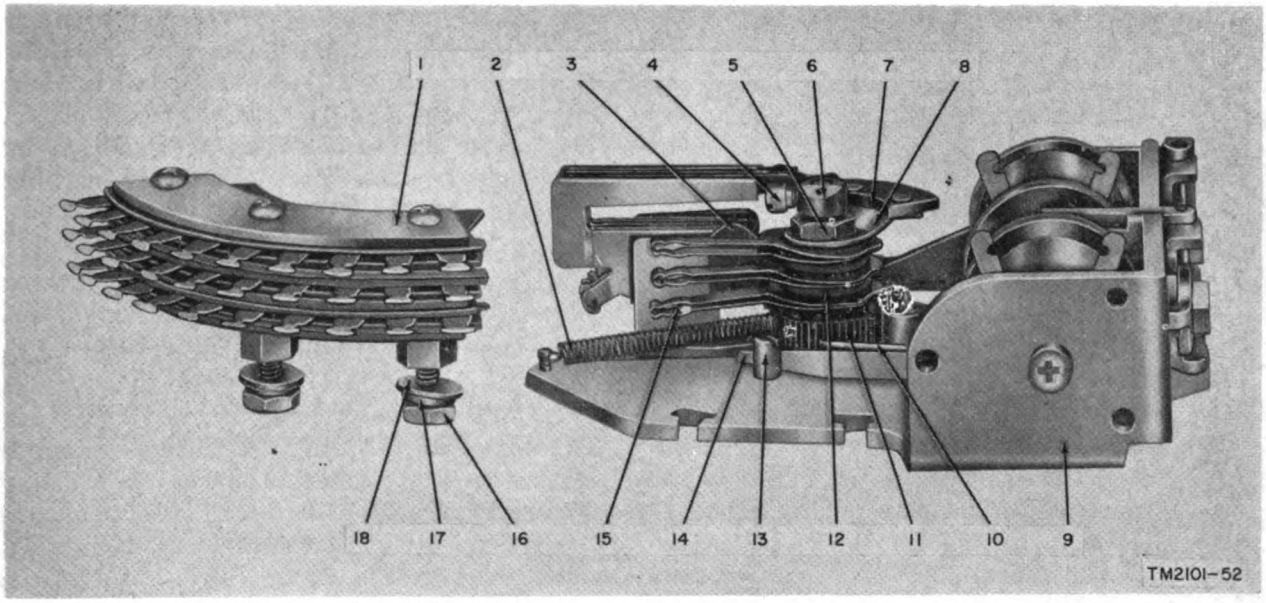
Figure 51. Minor switch, top and bottom view.

1 Off-normal spring combination assembly
2 Rotary armature return spring
3 Driving pawl
4 Driving pawl spring
5 Pawl stop
6 Return spring retaining screw (2, 4–40 x ⅛ inch)
7 Return spring lock washer
8 Rotary magnet
9 Rotary armature assembly
10 Rotary armature assembly retaining screw (6–32 x 3/32 inch)
11 Rotary armature assembly washer
12 Rotary magnet lock washer
13 Rotary magnet retaining screw
14 Release armature assembly
15 Release armature assembly retaining screw (2, 6–32 x 1/16 inch)
16 Release armature assembly washer
17 Release magnet
18 Release pawl
19 Rotary armature return spring
20 Release magnet retaining screw
21 Release magnet lockwasher
22 Wiper assembly stop arm
23 Restoring spring
24 Wiper assembly
25 Off-normal spring combination assembly retaining screw (2, 6–32 x 3/32 inch)
26 Off-normal spring combination assembly lock washer
27 Pawl stop washer
28 Pawl stop retaining screw
29 Mounting plate
30 Stop pin locking nut

Figure 51—Continued.

b. Bank Assembly (fig. 52). The bank assembly (1) is fastened to the mounting plate (9) by the two bank assembly washers (18), lockwashers (17), and retaining nuts (16). The bank assembly is comprised of three banks, identified as the top, middle and bottom levels. Each level has one common contact and 10 separate contacts, which are numbered 1 through 10 from right to left.

c. Restoring Spring (fig. 51). The restoring spring (23) is located between the notched post fastened to the mounting plate (29) and the tab on the wiper assembly stop arm (22). The restoring spring serves to return the wiper assembly (24) to the normal (unoperated) position, following the operation of the release magnet (17).



1 Bank assembly
2 Return spring
3 Stop arm
4 Collar retaining screw
5 Wiper assembly retaining nut
6 Collar
7 Off-normal cam
8 Wiper assembly
9 Mounting plate
10 Release pawl
11 Ratchet gear
12 Spacer (7)
13 Stop pin
14 Rotary armature return spring
15 Wiper (6)
16 Bank assembly retaining nut (2)
17 Bank assembly lock washer (2)
18 Bank assembly washer (2)

Figure 52. Minor switch, side view.

d. Wiper Assembly (fig. 52). The wiper assembly (8) is fastened to the bearing shaft which is fastened to the mounting plate (9) by the collar (6) and collar retaining screw (4). The wiper assembly consists of the parts listed in (1) through (7) below.

(1) *Ratchet gear.* The bushing (14, fig. 53) which is fastened to the shaft of the ratchet gear (11, fig. 52) mounts the parts of the wiper assembly (8). The ratchet gear positions the wipers (15) in the bank assembly (1) in each of the three levels through the action of the driving pawl (3, fig. 51) and returns the wiper to the normal position through the action of the release pawl (10, fig. 52).

(2) *Stop arm.* The stop arm (3) is fastened to the shaft of the ratchet gear (11). The stop arm determines the at rest position of the wiper assembly (8) in the unoperated position.

(3) *Bushing.* The bushing (14, fig. 53) is fastened to the shaft of the ratchet gear (11, fig. 52). The bushing mounts the wiper (15) and spacer (12) of the wiper assembly, insulating them from the rest of the assembly.

(4) *Wiper.* The three paired wipers (15) are fastened to the bushing. The wipers provide an electrical connection to the contacts in each of the three levels.

(5) *Spacer.* The seven spacers (12) are fastened to the bushing. The spacers between each pair of wipers (15) insulate the adjacent pairs from each other and position the wipers with respect to the levels in the bank assembly (1).

(6) *Off-normal cam.* The off-normal cam (7) is fastened to the bushing and insulated from the wipers by three spacers. The off-normal cam operates the off-normal spring combination when the wiper assembly moves to the off-normal (operated) position in the bank assembly.

(7) *Wiper assembly retaining nut.* The wiper assembly retaining nut (5) fastens the parts of the wiper assembly to the shaft of the ratchet gear.

e. Rotary Armature Assembly (fig. 51). The rotary armature assembly (9) is fastened to the mounting plate (29) by the rotary armature assembly retaining screw and washer (10 and 11). The rotary armature assembly consists of the yoke and armature, fastened together by a nonremovable pivot pin; the rotary armature return spring (2), fastened to the armature portion of the assembly by two return spring lockwashers and retaining screws (6 and 7); and the driving pawl and spring (3 and 4), fastened to the end of the armature by a nonremovable pivot pin. When the armature is attracted to the coil core of the rotary magnet, the driving pawl engages the teeth of the ratchet gear. This action operates the wiper assembly to the off-normal position in the bank assembly. The stop and driving pawl springs maintain the driving pawl against the radial face of the tooth. The return spring, tensioned during rotary magnet operation, returns the armature assembly to the rest position.

f. Rotary Pawl Stop (fig. 51). The pawl stop (5) is fastened to the mounting plate (29) by the pawl stop washer and retaining screw (27 and 28). The pawl stop limits the movement of the driving pawl.

g. Rotary Magnet (fig. 51). The rotary magnet (8) is fastened to the mounting plate (29) by the rotary magnet lockwasher and retaining screw (12 and 13). The rotary magnet attracts the rotary armature assembly (9) to the coil core each time the rotary magnet is energized.

h. Release Armature Assembly (fig. 51). The release armature assembly (14) is fastened to the mounting plate (29) by the release armature assembly retaining screw and washer (15 and 16). The release armature assembly consists of the yoke and release pawl (18), fastened together by a nonremovable pivot pin; and the rotary armature return spring (19), fastened to the release pawl by two rivets. When the armature is attracted to the coil core of the release magnet, the release pawl disengages from the teeth of the ratchet gear (11, fig. 52). The restoring spring (23, fig. 51), tensioned during rotary magnet operation, returns the wiper assembly (8, fig. 52) to the normal position in the bank assembly (1) when the release magnet operates.

i. Release Magnet (fig. 51). The release magnet (17) is fastened to the mounting plate (29) by the release magnet retaining screw and lock-

washer (20 and 21). The release magnet attracts the release armature assembly (14) to the coil core each time the release magnet is energized.

j. Stop Pin (fig. 52). The stop pin (13) is fastened to the mounting plate (9) by the stop pin locking nut (30, fig. 51). The stop pin limits the travel of the wiper assembly (8, fig. 52) when returned to the normal position. The rotary armature return spring (14) rides on the stop pin and assists in the positioning of the release pawl (10).

k. Off-Normal Spring Combination Assembly (fig. 51). The off-normal spring combination assembly (1) is fastened to the mounting plate (29) by the off-normal spring combination assembly retaining screw and lockwasher (25 and 26). The assembly consists of two spring combinations, an A combination and C combination. The contact springs are numbered one through five, from top to bottom.

123. Operation

The minor switch operates so that an electrical connection is made sequentially by a wiper assembly moving over bank contacts. At the completion of the operating cycle, the wiper assembly returns to the normal (nonoperated) position in the bank assembly. The mechanical operations of the minor switch are described below.

a. Stepping Action. When a pulse of current is extended to the rotary magnet, the wiper assembly is stepped in a clockwise direction to the next contacts in each of the three levels of the bank assembly.

(1) The rotary armature assembly is attracted to the coil core of the rotary magnet. This action tensions the return spring, preparing it for the return action. Simultaneously, the driving pawl, attached to the end of the armature by a pivot pin, engages the ratchet gear tooth.

(*a*) The driving pawl, maintained against the face of the tooth by the driving pawl spring, is driven into the root of the tooth.

(*b*) The driving pawl travel, limited by the pawl stop, rotates the ratchet gear one step in a clockwise direction.

(*c*) When the pulse is ended, the return spring moves the rotary armature assembly to its unoperated position, with the stop arm of the driving pawl resting against the flange of the mounting plate.

(2) During the first step taken by the wiper assembly, the wipers move onto the first contact in each of the three levels of the bank assembly. Simultaneously, the off-normal cam (part of the wiper assembly) operates the interrupter spring combination assembly.

(3) Simultaneously with the action taken in (1) and (2) above, the release pawl slides over the face of the ratchet gear tooth, engaging the next tooth at the end of each step taken in the clockwise direction. The release pawl return spring holds the release pawl into the root of the tooth.

(4) The restoring spring is tensioned by the clockwise rotation of the wiper assembly. This action prepares the wiper assembly for the releasing action.

b. Release Action. When a pulse of current is extended to the release magnet, the wiper assembly is returned to the normal position in the bank assembly.

(1) The release armature assembly is attracted to the coil core of the release magnet. This action tensions the release pawl return spring riding on the stop pin, preparing it for the return action.

(2) The release pawl (an integral part of the release armature assembly) disengages from the ratchet tooth. This action releases the tension wound into the restoring spring.

(3) The wiper assembly returns to the normal position in the bank assembly, with the wiper assembly stop arm resting against the stop pin.

(4) When the pulse is ended the release pawl return spring moves the release armature assembly to its unoperated position. The off-normal cam releases the interrupter spring combination assembly.

124. Disassembly (fig. 53)

a. Bank Assembly.

(1) Operate the wiper assembly to the normal position in the bank assembly.

(2) Unsolder the tag and leads to the bank assembly contacts.

(3) Use the end wrench to loosen the two bank assembly retaining nuts (1).

Note. To remove the bank assembly it is not necessary to remove the two bank assembly retaining nuts or washers (1, 2, and 3).

(4) Slide the bank assembly (4) down and away from the wiper assembly.

Note. The bank assembly is replaced as an assembly.

b. Wiper Assembly.

(1) Use the long-nosed pliers to remove the restoring spring (5) from the mounting plate pin.

(2) Loosen the collar retaining screw (6).

Note. The collar retaining screw need not be removed to disassemble the wiper assembly.

(3) Remove the wiper assembly (8) by removing the collar (7) and sliding the assembly off the shaft of the ratchet gear (15).

(4) Use an end wrench to remove the wiper assembly retaining nut (9).

(5) Remove the off-normal cam (10), spacers (11 and 12), and wipers (13) from the bushing (14).

(6) Remove the ratchet gear (15) from the bushing and remove the wiper assembly stop arm (16).

c. Rotary Armature Assembly.

(1) Use the end wrench to remove the rotary armature retaining screw and key washer (17 and 18).

(2) Slide the rotary armature assembly (19) free from its mounting.

(3) Remove the rotary armature return spring (22) by removing the two return spring retaining screws and lockwashers (20 and 21).

d. Pawl Stop.

(1) Use an end wrench to remove the pawl stop retaining screw, lockwasher, and washer (23, 24, and 25).

(2) Remove the pawl stop (26) from the slot in the mounting plate (50).

e. Rotary Magnet.

(1) Unsolder and tag the leads to the rotary magnet.

(2) Use an end wrench to remove the rotary magnet retaining screw and lockwasher (27 and 28).

(3) Lift the rotary magnet (29) free from mounting plate (50).

f. Release Armature Assembly.

(1) Use an end wrench to remove the release armature retaining screw and key washer (30 and 31).

(2) Lift the release armature assembly (32) free from the mounting plate (50).

g. Release Magnet.

(1) Unsolder and tag the leads to the release magnet.

(2) Use a Phillips screwdriver to remove the release magnet retaining screw and lockwasher (33 and 34).

(3) Lift the release magnet (35) free from mounting plate (50).

h. Stop Pin.

(1) Use an end wrench to retain the stop pin locking nut (37).

(2) Use a screwdriver to unscrew the stop pin (36), and remove the stop pin locking nut.

i. Off-Normal Spring Combination Assembly.

(1) Unsolder and tag the leads to the off-normal spring combination assembly.

(2) Use an end wrench to remove the two off-normal spring combination assembly retaining screws, and lockwashers (38 and 39) and lift the off-normal spring combination assembly (40) free from the mounting plate (50).

(3) Use a Phillips screw driver to remove the two retaining screws (41).

(4) Remove the insulator (42), pressure plate (43), spacers (44), contact springs (45), follow spring (46), plunger spring (47), and stop spring (48) from the bracket (49).

125. Reassembly
(fig. 53)

The reassembly instructions provide for the rough adjustment of all parts and assemblies. Specific adjustment instructions are given in paragraphs 127 through 133 and must be performed before the minor switch can be put in service.

a. Off-Normal Spring Combination Assembly.

(1) Place one each of the two insulators (42) on the two retaining screws (41).

(2) Slip the two retaining screws into the pressure plate (43) and invert the assembled parts.

(3) Slip the first spacer (44), first contact spring (45), second spacer (44), follow spring (46), third spacer (44), second contact spring (45), fourth spacer (44), plunger spring (47), fifth spacer (44), stop spring (48), and sixth spacer (44) onto the two insulators.

(4) Hold the assembled parts together and position them over the mounting holes in the bracket (49).

(5) Use a Phillips screwdriver to fasten the two retaining screws to the bracket.

(6) Fasten the bracket to the mounting plate (50) with the two off-normal spring combination assembly retaining screws and lockwashers (38 and 39).

(7) Operate the plunger spring: contacts 1–2 should make, 3–4 should make, and 4–5 should break.

b. Wiper Assembly.

(1) Place the wiper assembly stop arm (16) on the shaft of the ratchet gear (15) and insert the clip which secures one end of the restoring spring (5) in the slot.

(2) Place the bushing (14) on the shaft against the face of the wiper assembly stop arm.

(3) Place the first set of paired wipers (13), two $\frac{1}{16}$-inch spacers (12), the second set of paired wipers (13), the next two $\frac{1}{16}$-inch spacers (12), the third set of paired wipers (13) and three $\frac{1}{64}$-inch spacers (11) on the shaft of the bushing (14).

(4) Place the off-normal cam (10) on the shaft of the ratchet gear (15).

(5) Use an end wrench to fasten the wiper assembly retaining nut (9) on the shaft of the ratchet gear.

(6) Place the wiper assembly (8) on the bearing shaft.

c. Bank Assembly.

(1) Insert the bank assembly (4) into the two slots on the mounting plate (50).

(2) Fasten the bank assembly with the two bank assembly retaining nuts, lockwashers, and washers (1, 2, and 3).

(3) Tighten the two bank assembly retaining nuts lightly.

(4) Operate the wiper assembly to the normal position on the bank (extreme counterclockwise position).

(5) Reposition the off-normal cam (10), if necessary. In the correct position, the cam is flush with the plunger spring (47). To reposition, follow the procedures listed in (6) and (7) below. If unnecessary, follow steps (8) and (9) only.

(6) Use an end wrench to loosen the wiper assembly retaining nut (9).

(7) Carefully reposition the off-normal cam and retighten the wiper assembly retaining nut.

(8) Place the collar (7) on the shaft of the ratchet gear and line up the two oil holes.

(9) Fasten the collar to the shaft with the collar retaining screw (6).

d. Rotary Magnet.

(1) Position the rotary magnet (29) over the mounting hole in the mounting plate (50).

(2) Use an adjustable open-end wrench to fasten the rotary magnet to the mounting plate with the rotary magnet retaining screw and lockwasher (27 and 28).

e. Rotary Armature Assembly.

(1) Position the rotary armature return spring (22) over the mounting holes in

the rotary armature assembly (19), with the edge of the spring flush with the armature.

(2) Fasten the rotary armature return spring to the armature assembly with the two return spring retaining screws and lockwashers (20 and 21).

(3) Slip the rotary armature return spring over the mounting flange and the stop under the mounting flange.

(4) Place the yoke over the right side mounting hole in the mounting plate.

(5) Use an end wrench to fasten the assembly in place with the rotary armature retaining screw and key washer (17 and 18).

f. Pawl Stop.

(1) Move the rotary armature assembly to the operated position.

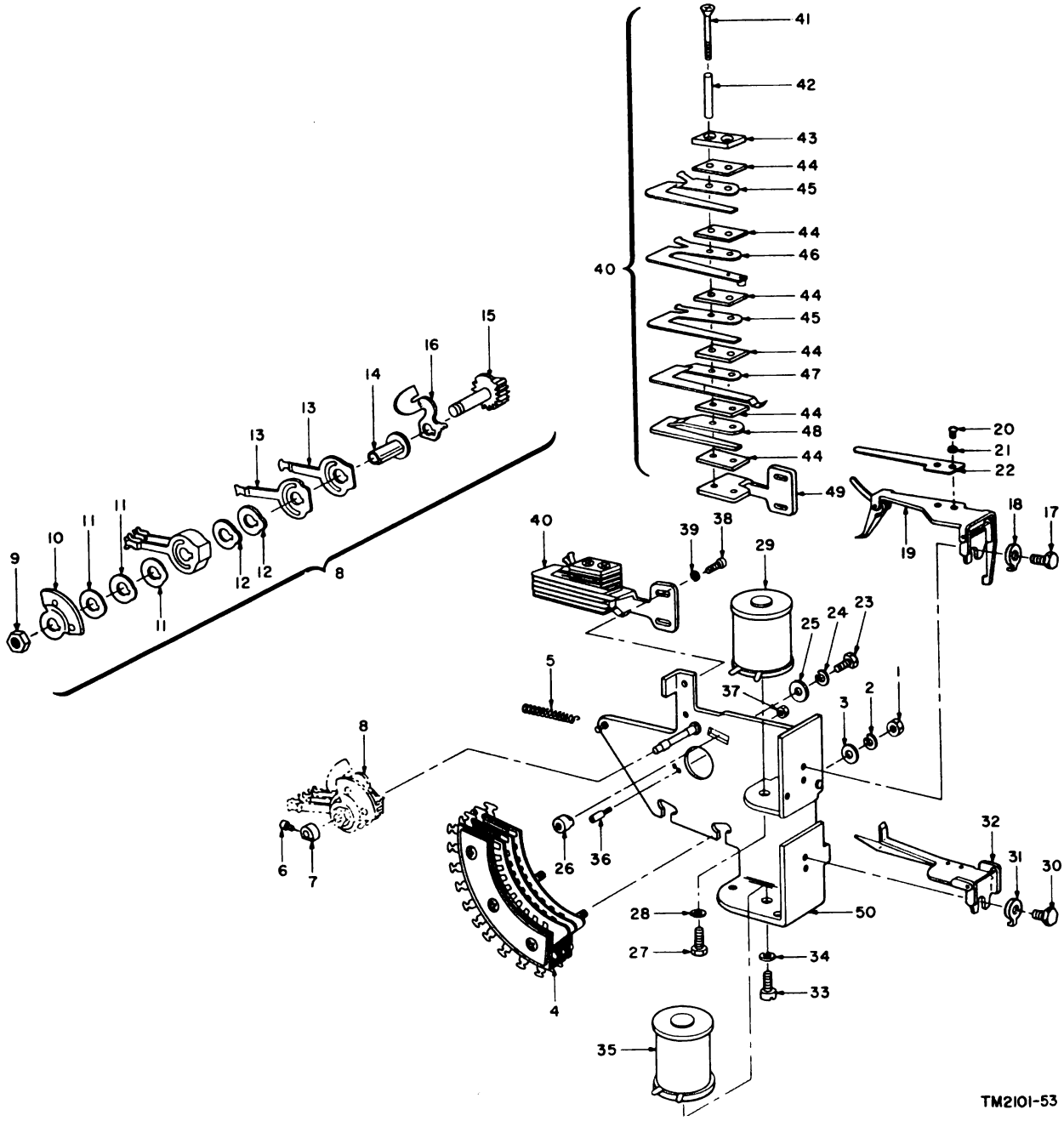


Figure 53. Minor switch, exploded view.

1 Bank assembly retaining nut (2)
2 Bank assembly lock washer (2)
3 Bank assembly washer (2)
4 Bank assembly
5 Restoring spring
6 Collar retaining screw
7 Collar
8 Wiper assembly
9 Wiper assembly retaining nut
10 Off-normal cam
11 Spacer (4)
12 Spacer (4)
13 Wiper (6)
14 Bushing
15 Ratchet gear
16 Wiper assembly stop arm
17 Rotary armature retaining screw (2, 6–32 x 5/16 inch)
18 Rotary armature key washer
19 Rotary armature assembly
20 Return spring retaining screw (2, 4–40 x 1/8 inch)
21 Return spring lock washer (2)
22 Rotary armature return spring
23 Pawl stop retaining screw
24 Pawl stop lock washer
25 Pawl stop washer
26 Pawl stop
27 Rotary magnet retaining screw
28 Rotary magnet lock washer
29 Rotary magnet
30 Release armature retaining screw (2, 6–32 x 5/16 inch)
31 Release armature key washer
32 Release armature assembly
33 Release magnet retaining screw
34 Release magnet lock washer
35 Release magnet
36 Stop pin
37 Stop pin locking nut
38 Off-normal spring combination assembly retaining screw (2, 6–32 x 3/32 inch)
39 Off-normal spring combination assembly lock washer (2)
40 Off-normal spring combination assembly
41 Retaining screw
42 Insulator
43 Pressure plate
44 Spacer (6)
45 Contact spring (2)
46 Follow spring
47 Plunger spring
48 Stop spring
49 Bracket
50 Mounting plate

Figure 53—Continued.

(2) Place the pawl stop (26) in the slot in the mounting plate and slide it to the left until flush with the driving pawl.

(3) Return the rotary armature assembly to the normal position while holding the pawl stop in position.

(4) Use an end wrench to fasten the pawl stop in place with the pawl stop retaining screw (23) and stop washer.

g. Release Magnet.

(1) Position the release magnet (35) over the mounting hole in the mounting plate (50).

(2) Use a Phillips screwdriver to fasten the release magnet to the mounting plate with the release magnet retaining screw and lockwasher (33 and 34).

h. Stop Pin.

(1) Screw the stop pin (36) into one of the two mounting holes in the mounting plate (50).

(2) Use an end wrench to fasten the stop pin locking nut (37).

i. Release Armature Assembly.

(1) Position the return spring on the top of the stop pin (36) and the yoke over the mounting hole in the right side of the mounting plate (50).

(2) Use an end wrench to fasten the release armature assembly (32) to the mounting plate with the release armature retaining screw and key washer (30 and 31).

(3) Operate the rotary armature assembly, while moving the wiper assembly into the bank.

(4) Operate the release armature assembly and check to see that the wiper assembly is returned to its normal position in the bank.

(5) Reposition the relase armature assembly, or move the stop pin to the second mounting hole, if necessary.

126. Adjustments

The checks and adjustments described below are applicable to new switches being installed and to switches which have been repaired. The

checks and adjustments should be performed sequentially in the order listed. Where an adjustment affects an associated part or assembly, both should be checked for proper adjustment before proceeding. Perform the final testing (par. 134) on the minor switch before returning the switch to service.

127. Adjustment of Wiper Assembly (Removed)

The following checks and adjustments should be performed when the wiper assembly is removed from the bearing shaft and before it is reassembled to the mounting plate.

a. Checks (fig. 54). Check to see that—

(1) The wipers are approximately straight and have no bends or kinks.

(2) The deflection of one of the paired wipers will cause the second to follow by 1/16 inch.

(3) The paired wipers touch.

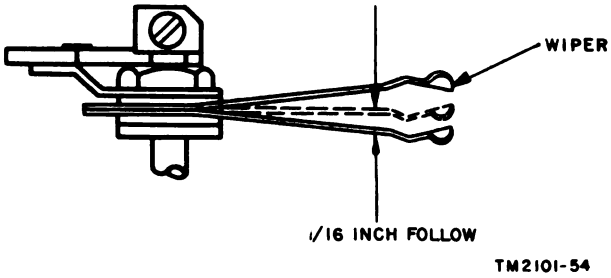


Figure 54. Contact follow.

b. Adjustment Procedures.

(1) Use an end wrench to loosen the wiper assembly retaining nut.

(2) Shift the wipers.

(3) Tighten the wiper assembly retaining nut.

(4) Use a spring adjuster tool to tension the wipers for the proper follow.

(5) Adjust for proper contact follow (*a* (2) above) between paired wipers and readjust, if necessary.

128. Adjustment of Wiper Assembly (Reassembled)

The following checks and adjustments should be made when the wiper assembly is reassembled to the mounting plate.

a. Checks (fig. 55).

(1) Check the wipers for proper vertical alinement within 1/64 inch.

(2) Use a gage to check the wipers for 15 grams of pressure (minimum) on the bank contacts.

(3) See that the wiper assembly stop arm is approximately centered on the stop pin when the wiper assembly is in normal position.

(4) Check to see that the oilholes in the collar and bearing shaft are alined.

(5) Check to see that the vertical play of the wiper assembly on the bearing shaft is not more than .005 inch. Gage by feel.

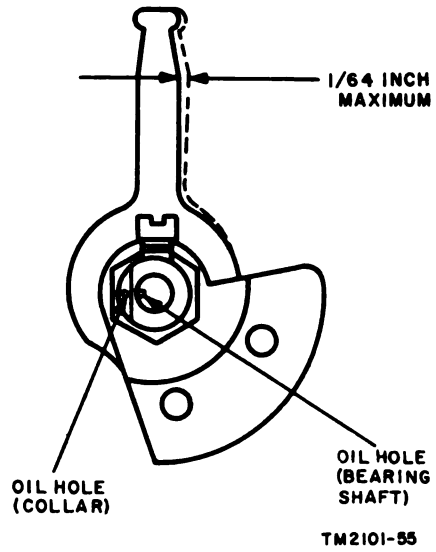


Figure 55. Vertical alinement.

b. Adjustment Procedures.

(1) Loosen the collar retaining screw and remove the collar.

(2) Position and tension the wipers in accordance with the instructions listed in paragraph 26*b*.

(3) Aline the oilholes in the collar and bearing shaft and fasten them with the collar retaining screw.

(4) Using a gage recheck the end play of the wiper assembly on the bearing shaft for .005-inch maximum.

(5) Use duckbill pliers or a spring adjuster tool to realine the wiper assembly stop arm.

(6) Operate the switch to the normal position and recheck the position of the stop arm with respect to the stop pin.

129. Adjustment of Bank Assembly

a. Checks (fig. 56). Check to see that—

(1) The bank assembly is located so that the wipers pass over the approximate center of each embossed section of bank insulator and come to rest on the center of each successive contact.

(2) The wiper assembly in the normal position in the bank is one step from the first contact.

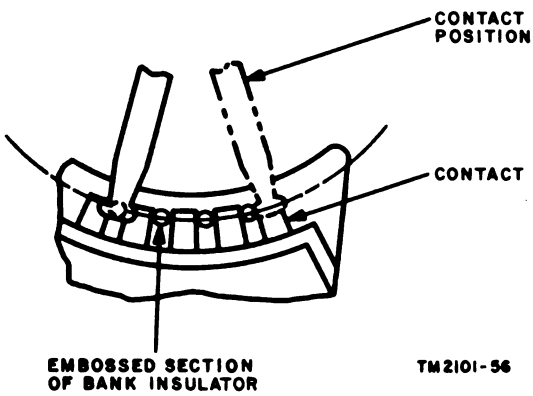


Figure 56. Position of wipers in bank.

b. Adjustment Procedures.

(1) Operate the wiper assembly to the first bank contact (fig. 56) (off-normal position).

(2) Use an end wrench to loosen the two bank assembly retaining screws.

(3) Reposition the bank assembly so that the wipers ride on the center of the bank contact.

(4) Retighten the two bank assembly retaining screws.

(5) Operate the rotary armature assembly by hand and check to see that the wipers move over the center of the embossed section of the bank insulator.

(6) Operate the wiper assembly to the normal position and then reoperate it to the off-normal position; check to see that the wipers move freely onto the center of the first and each successive contact in each of the three levels.

130. Release Armature Assembly

a. Checks (fig. 57).

(1) Check to see that the release armature assembly is free to move on the pivot pin with a perceptible side play.

(2) Check the release armature air line by eye for a minimum of .004 inch over the entire width.

(3) Check to see that release stroke is .020 ± .002 inch.

(4) See that the tip of the release pawl is approximately parallel to the ratchet gear teeth.

(5) Use a gage to check the release armature spring for 75 to 125 grams of pressure against the stop pin.

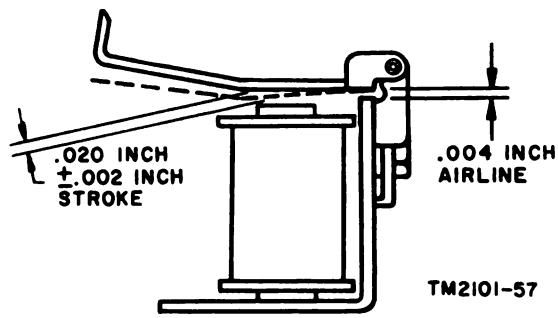


Figure 57. Release armature stroke and air line tolerances.

b. Adjustment Procedures.

(1) Use an end wrench to loosen the release armature retaining screw.

(2) Adjust the release armature assembly for the proper air line, make sure that the two surfaces are parallel.

(3) Retighten the release armature retaining screw.

(4) Use a spring adjuster tool to tension the release armature spring.

(5) Recheck the engagement of the release pawl with the ratchet gear.

(6) Use duckbill pliers to adjust the travel of the release armature assembly for .020 ± .002 inch.

131. Rotary Armature Assembly

a. Checks (fig. 58).

(1) Check to see that the rotary armature assembly is free to move on the pivot

pin with a perceptible side play.

(2) Check the rotary armature air line by eye for a minimum of .004 inch over the entire width.

(3) See that the rotary armature stroke is approximately .030 inch as follows:

(*a*) Place a .0015-inch gage between the armature and the coil core, then operate the rotary armature assembly by hand and check to see that the driving pawl drops into the next ratchet gear tooth.

(*b*) Place a .004 gage between the armature and coil core, then operate the rotary armature assembly by hand and check to see that the driving pawl does *not* drop into the next ratchet gear tooth.

(4) Use a gage to check the rotary armature return spring for 130 to 200 grams of presure against the mounting flange.

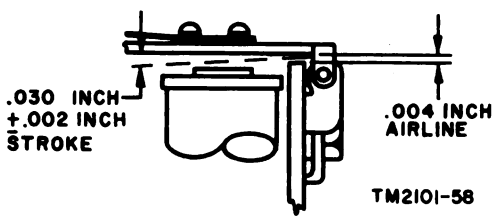


Figure 58. Rotary armature stroke and air line tolerances.

b. Adjustment Procedures.

(1) Use an end wrench to loosen the rotary armature retaining screw.

(2) Adjust the rotary armature assembly for the proper air line, make sure that the two surfaces are parallel.

(3) Retighten the rotary armature retaining screw.

(4) Use a spring adjuster tool to tension the rotary armature return spring.

(5) Recheck the engagement of the driving pawl with the ratchet gear teeth.

(6) Use duckbill pliers to adjust the travel of the rotary armature assembly for .030 inch.

132. Adjustment of Driving Pawl

a. Checks (fig. 59)

(1) See that the driving pawl is free to move on its pivot pin.

(2) Check to see that driving pawl is parallel to the ratchet gear teeth.

(3) Use a gage to check the stop for 50 to 100 grams of pressure against the underside of the mounting flange.

(4) Check the engagement of the driving pawl with the ratchet gear teeth so that the pawl strikes the approximate center of the radial face and then slides down into the root of the tooth when the rotary armature assembly is operated by hand.

(5) Recheck the requirement in (4) above at each of the 10 steps.

(6) Check to make sure that the rotary armature assembly strikes the core before the driving pawl strikes the pawl stop.

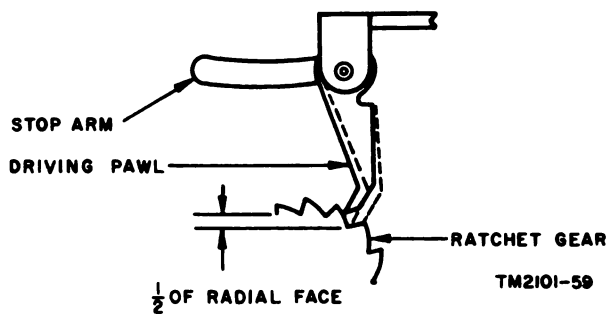


Figure 59. Driving pawl action.

b. Adjustment Procedures.

(1) Use duckbill pliers to adjust the position of the stop, both for pressure against the mounting flange and for position of the driving pawl when engaging the ratchet gear teeth.

(2) Use long-nosed pliers to tension the driving pawl spring.

133. Adjustment of Off-Normal Spring Combination Assembly

a. Checks (figs. 60 and 61).

(1) Operate the wiper assembly to the first bank contact and check for a .005- to .015-inch clearance between the stop spring and plunger spring.

(2) Operate the wiper assembly to the normal position and check for a perceptible clearance (by eye) between the off-normal cam and the plunger spring.

(3) Check for a .010 clearance between plunger and follow spring with the wiper assembly in the normal position.
(4) Check for the same condition as in (3) above between the contact and follow springs.
(5) Use a gage to check to see that the break pressure is 30 grams and the make pressure 20 grams minimum.
(6) Operate the wiper assembly onto each of the 10 bank contacts and recheck in accordance with (1) above.

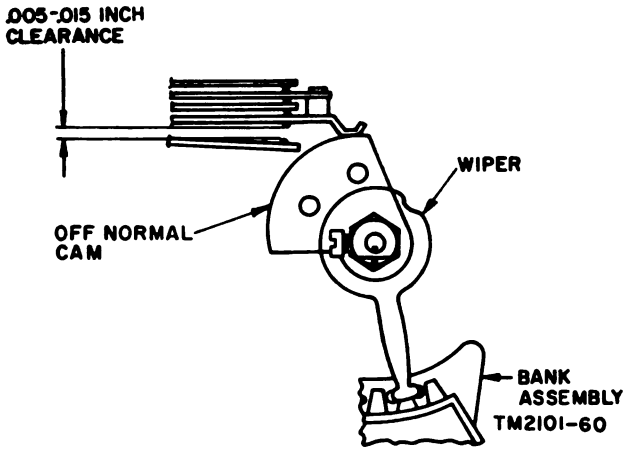


Figure 60. Spring combination assembly (off-normal position).

b. Adjustment Procedures.

(1) Loosen the collar retaining screw and remove the collar.
(2) Use an end wrench to loosen the wiper assembly retaining nut.
(3) Reposition the off-normal cam with the wiper assembly in the normal position.
(4) Retighten the wiper assembly retaining nut and fasten the wiper assembly with the collar and collar retaining nut.
(5) Recheck the wiper assembly end play.
(6) Use a spring adjuster tool to tension the contact, follow, plunger, and stop springs for the proper break and make pressure.
(7) Recheck the contact separation.

134. Final Testing

Bench service final testing is performed with the minor switch removed from the equipment. The operational final tests are performed at the completion of the adjustments and before the switch is returned to service.

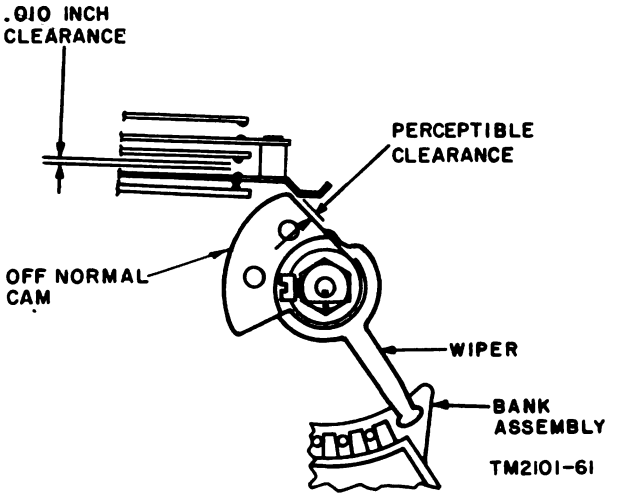


Figure 61. Spring combination assembly (normal position.)

a. Bench Service Testing.

(1) Connect the minor switch for the test setup in accordance with figure 62.
(*a*) Connect negative battery (BA) to one side of the momentary push-to-make switches (S1 and S2).
(*b*) Connect the other side of BA to ground.
(*c*) Connect the other side of S2 to terminal C of RX, brush spring terminal of the rotary switch (S5), and terminal 4 of the interrupter springs (S4).
(*d*) Connect terminal A of RX to terminal 1 of the interrupter springs (S6).
(*e*) Connect a 200 ohm resistor in series with a 1-μf capacitor across terminals 2 of S6 and A of RX.
(*f*) Connect terminal 2 of S6 to ground.
(*g*) Connect terminals 1, 5, 10, and 15 of S5 to the other side of S1.
(*h*) Connect terminal C of the X magnet to the wiper of the top bank of the minor switch.
(*i*) Connect terminal A of the X magnet to ground.
(*j*) Connect terminals 1 through 9 to one side of the peg count meter.
(*k*) Connect the other side of the peg count meter to ground.

(*l*) Connect terminal A of the release magnet to terminal 1 of S4.

(*m*) Connect terminal C of the release magnet to terminal 10 of the top bank of the minor switch.

(*n*) Connect terminal 2 of S4 to ground.

(*o*) Connect terminal 3 to one side of the lamp (DS1).

(*p*) Connect terminal 5 to one side of the lamp (DS2).

(*q*) Connect the other side of lamps DS1 and DS2 to ground.

(2) Operate switch S1. The wiper assembly should rotate over the bank contacts, registering one digit on the peg count meter for each step taken. On step 10, the wiper assembly should return to the normal position in the bank assembly. In the normal position, DS2 should light and DS1 should be extinguished. In the off-normal position, DS1 should light and DS2 should be extinguished.

(3) Restore S1.

(4) Operate switch S2 for 1 minute to make a speed test of the minor switch. The meter should register 600 ± 120 counts.

(5) Restore S2.

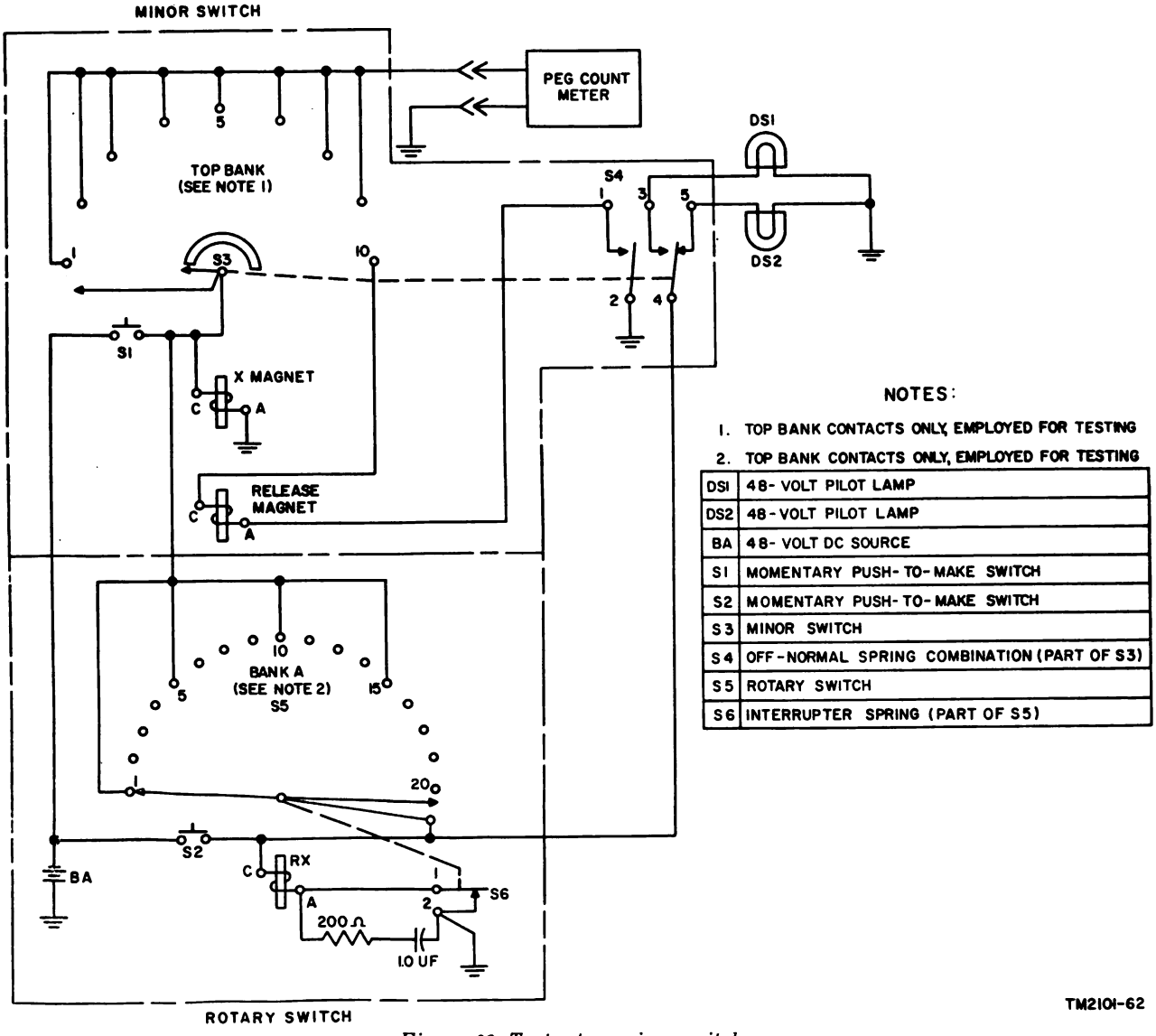


Figure 62. Test setup, minor switch.

(6) Repeat (1) through (5) above for the middle and bottom levels of the minor switch.

b. Operational Testing. Operational testing is accomplished by routining the circuit associated with the minor switch. During routining, the minor switch is stepped 10 steps in the off-normal direction and returned to the normal position either automatically or by an external switch, depending on its circuit application. For additional information, refer to TM 11–2119.

Section VIII. LEVER SWITCHES

135. Nomenclature and Function of Parts (fig. 63)

Lever switches are furnished in many combinations of switching arrangements to provide specific operations under manual control. The switches operate as either one-way or two-way levers in either locking or nonlocking (momentary) combinations. Except for the handle, individual parts are not replaceable.

a. Frame. The frame is the central supporting structure for the components of the switch. Four holes on the front of the frame are used to mount the switch.

b. Cam Key. The cam key is the operating mechanism and is fitted with a screw on the handle. The cam key is equipped with free action cam rollers to minimize wear. The cam roller operates each spring combination assembly. The cam key is fastened to the frame by means of the cam pin.

c. Spring Combination Assembly. The spring combination assembly is fastened together with mounting screws. The plunger spring is operated by the cam roller (bent plunger springs are provided for switches having a locking action and straight plunger springs are provided for

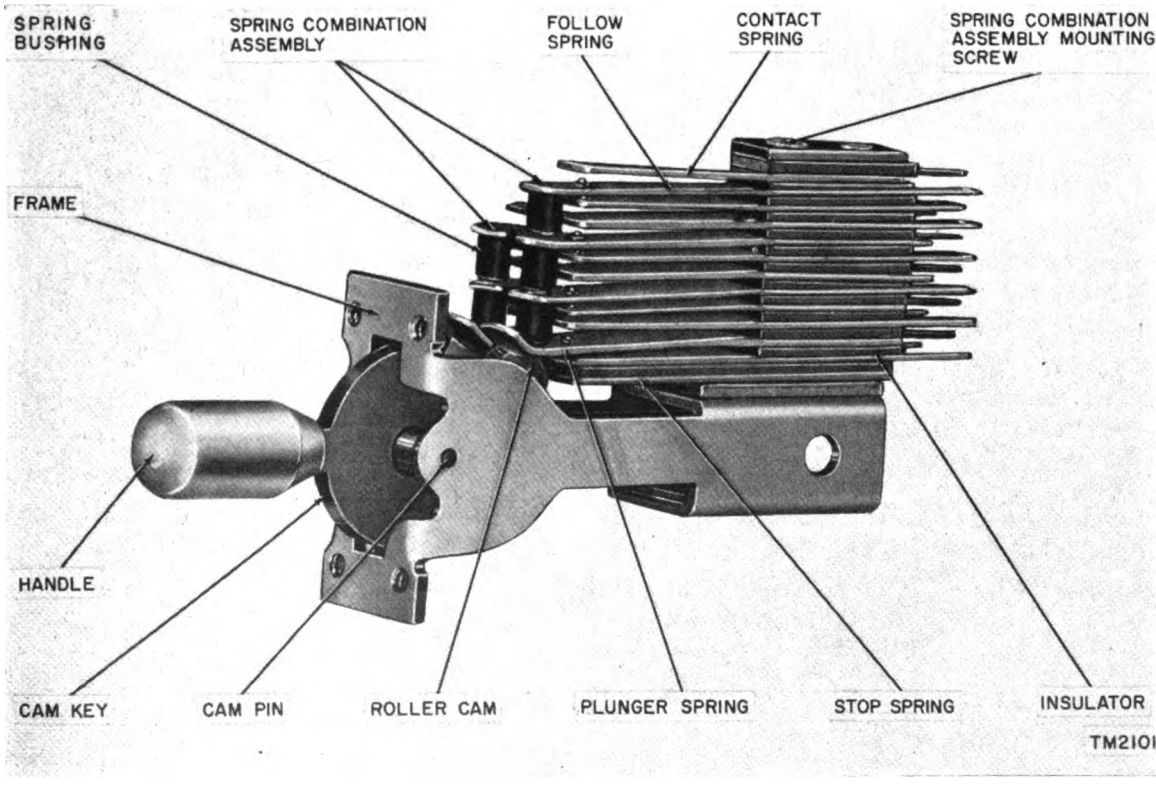


Figure 63. Lever switch.

switches having a momentary action.) Spring bushings impart motion to the follow springs. Stop springs limit the travel (follow) of the follow springs. The spring combination assembly uses various basic spring combinations (pileups) to build up a specific switching combination. One-way lever switches can operate two pileups. The two-way lever switches can operate four pileups, two for each throw.

136. Contact Numbering

The method of numbering the contact springs and terminals of the lever switch is shown in figure 64. A, (fig. 64) is a direct rear view of the switch and B, (fig. 64) is an inverted view of the switch as it appears when the keyboard is raised.

137. Method of Mounting

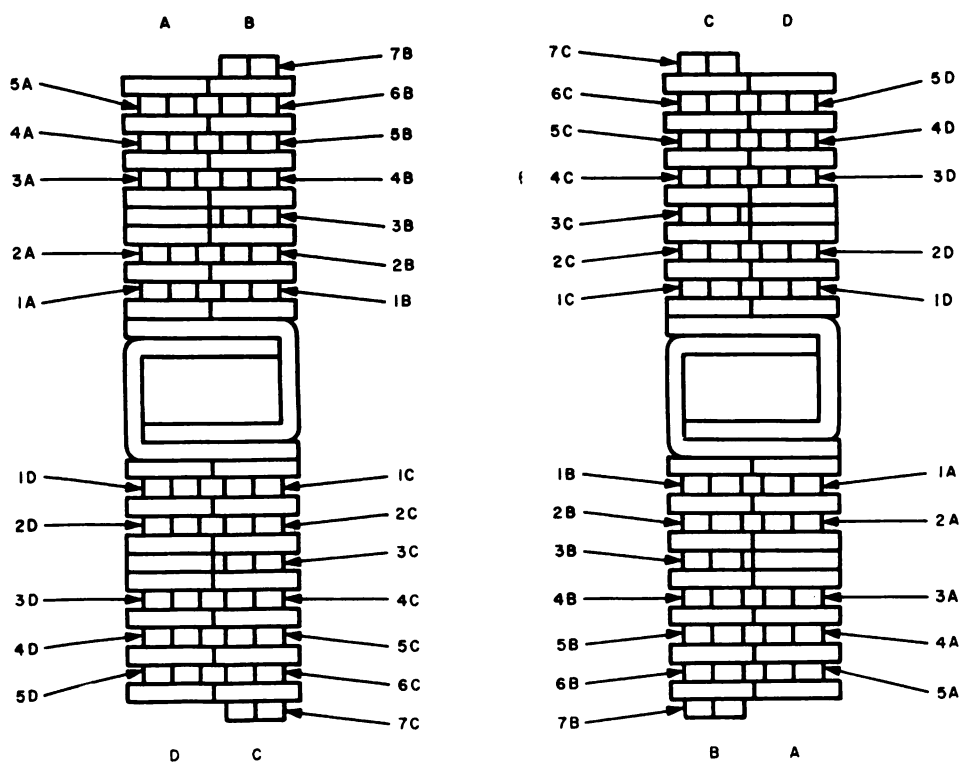
The lever switch is fastened by four flathead screws, through the four tapped holes on the frame. It is usually necessary to unscrew the switch handle from the cam key to pass the cam key through a slot in the keyboard or panel. If an escutcheon plate conceals the switch mounting holes, remove the escutcheon plate before mounting the switch. If the escutcheon plate is removed, refasten it before replacing the switch handle on the switch cam .

138. Operation

When the cam key is operated, pressure is applied by the cam roller against the plunger spring, and the spring contacts of the switch combination make or break, providing the electrical connections desired. When the cam key is restored, spring tension restores all the springs to the normal position.

139. Adjustments

Remove any switch requiring repair from its mounting and determine whether the switch is in need of adjustment or must be replaced because of excessive wear or damage. Before per-



A. DIRECT REAR VIEW.

B. INVERTED REAR VIEW (WITH KEYSHELF TURNED UP)

TM2101-64

Figure 64. Lever switch, cantact numbering.

forming any checks or adjustments, clean the switch and contacts.

a. Adjustment of Contact Alinement.

(1) *Checks.*

(*a*) See that the point of contact of each spring falls wholly within the boundary of the opposing contact.

(*b*) Gage the contact alinement of the contacts by eye.

(*c*) Check the contact alinement for all positions of the switch.

(*d*) Check to see that each plunger spring contacts the entire width of the roller cam when the switch is operated.

(2) *Adjustment procedure.*

(*a*) Loosen the two spring combination assembly mounting screws of the pileup.

(*b*) Shift the springs as required.

(*c*) Tighten the screws securely after the adjustment is completed.

b. Adjustment of Lever Action.

(1) *Checks.*

(*a*) Operate and then release the switch lever. The lever should return to an upright position.

(*b*) Check to see that the lever is held in the upright position by the pressure of the plunger springs against the cam rollers.

(*c*) See that the cam rollers do not have any flattened surface.

(*d*) Check to see that there is no appreciable lever side play.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to adjust the plunger spring.

(*b*) Bend the spring, near the insulator end, toward the cam roller so that the spring contacts the roller.

Note. Do not bend the spring more than necessary.

c. Adjustment of Contact Separation (fig. 65).

(1) *Checks.*

(*a*) Check the separation between all pairs of normally open contacts.

(*b*) Operate the switch and check the separation between all pairs of contacts that break when the switch is operated.

(*c*) Gage the separation by eye. The separation between any pair of contacts should be not less than .010 inch.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to adjust the contact separation.

(*b*) Bend the spring slightly in the required direction, applying pressure a short distance behind the contacts.

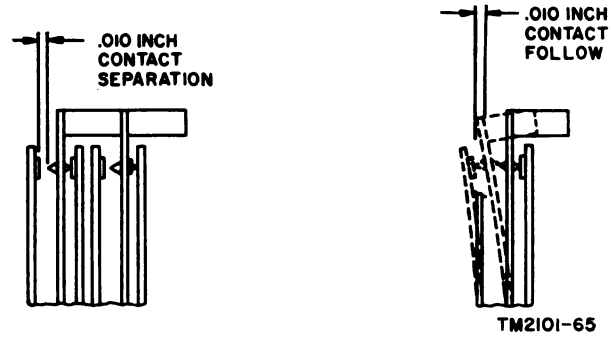


Figure 65. Lever switch contact and spring adjustments.

d. Adjustment of Contact Follow (fig 65).

(1) *Checks.*

(*a*) Check the follow of each contact spring from the moment of make, when the switch is operated.

(*b*) Check the follow of each contact when the switch is released.

(*c*) Gage the follow by eye; it should not be less than .010 inch for each contact spring. This requirement does not apply to a contact spring backed up by a heavier spring acting as a stop spring.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to adjust the contact follow.

(*b*) Make the inner spring adjustments before the outer spring adjustments.

(*c*) Bend the spring, near the insulator end, in the required direction.

e. Adjustment of Contact Sequence.

(1) *Checks.*

(*a*) Check to see that all closed contacts break before any open contacts make, except for make-before-break combinations.

(*b*) For make-before-break combinations, check to see that all open contacts make before the closed contacts break.

(*c*) See that the interval between make and break, except for make-before-break combinations, is not less than .006 inch.

Note. The interval is the distance the plunger and follow springs move while they are not in contact with a contact spring.

(*d*) Gage the interval between make and break by eye while operating and releasing the switch.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to correct the contact sequence and the make-break interval.

(*b*) Bend the spring slightly to achieve the required result.

f. Adjustment of Contact Pressure.

(1) *Checks.*

(*a*) Use a contact pressure gage to measure the contact pressure.

(*b*) Measure the contact pressure between all normally closed contacts.

(*c*) Operate the switch and check the contact pressure between all contacts that make when the switch is operated.

(*d*) The pressure between the make contacts must be at least 60 grams.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to correct hte contact pressure.

(*b*) Bend the spring near the insulator end in the required direction to increase the contact pressure.

140. Final Testing

After the checks and adjustments are completed, perform the final bench service test procedure using a buzzer with a self-contained 24-volt battery.

a. Operate and release the lever switch several times to insure stable operation of the springs.

b. Operate the lever to one side of normal.

c. Momentarily touch the buzzer leads successively across the terminals of the make contacts. The buzzer should sound each time.

d. Operate the lever switch to normal.

e. Momentarily touch the buzzer leads successively across the terminals of the break contacts. The buzzer should sound each time.

f. Operate the lever to the other side of normal (for two-way switches).

g. Momentarily touch the buzzer leads successively across the terminals of the make contacts. The buzzer should sound each time.

h. For two-way switches, operate the lever to one side of normal.

i. Check the unoperated pileups. The contact springs must maintain the same adjustment requirements as in the normal position.

j. Operate the lever to the other side of normal.

k. Check the unoperated pileups as in *i* above.

l. For switches with a nonlocking position, operate the switch to the nonlocking position and allow it to release quickly. It should release without binding and must not overtravel beyond normal and lock in the locking position.

Section IX. TURN SWITCH

141. Nomenclature and Function of Parts (fig. 66)

All turn switches (twist type keys) are of the one-way locking type. To operate the switch, the knob (plunger) is turned ¼-turn clockwise. A slot on the knob indicates whether the switch is in the operated or unoperated position.

a. Frame. The frame is the central supporting structure for the components of the switch. One end of the frame provides the support for the spring combinations which are assembled on both sides of the support. The other end of the frame is formed into a slotted collar, which accommodates the plunger. Two sets of tapped mounting holes on the side of the frame provide alternate locations for the mounting bracket.

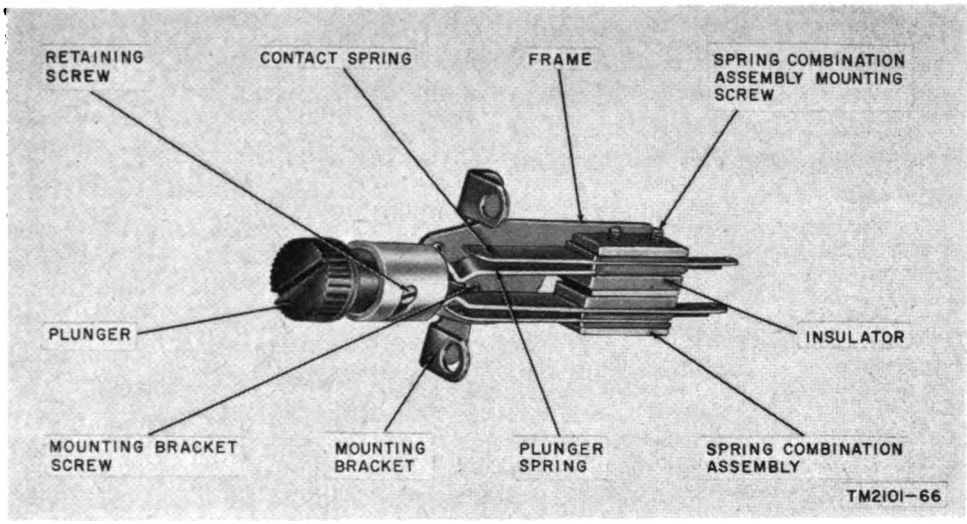


Figure 66. Turn switch.

b. Mounting Bracket. The mounting bracket is removable and is fastened by two screws through two holes on the frame. The bracket has two right-angle mounting feet.

c. Plunger. The plunger fits inside the collar of the frame and is held in place by the retaining screw on the side of the plunger. The retaining screw rides the slot in the collar. The slot and retaining screw limit rotation of the plunger to approximately 90°. One end of the plunger is slotted to indicate the operated and unoperated positions of the switch. The other end of the plunger has a rectangular cam which fits between the plunger springs of the spring combination assembly.

d. Spring Combination Assembly. The spring combination assembly (pileup) consists of the plunger and contact springs separated by insulators and fastened to the frame support by two spring combination assembly mounting screws. The spring combinations are placed on both sides of the frame support.

142. Contact Numbering

The method of numbering the contact springs and terminals of a typical turn switch is shown in figure 67. This is a rear view of a vertically mounted switch showing 2 A combinations (fig. 86) (contacts 1–2 and 3–4). Other spring combinations may be used on turn switches and will appear as shown. If the turn switch is mounted horizontally contact 1 appears at the left. Refer to the equipment wiring diagram to determine the mounting plane of the switch.

143. Methods of Mounting

The turn switch is equipped with a removable mounting bracket which is fastened to the side of the frame by means of two mounting bracket screws. Two pairs of tapped mounting holes on the frame provide two locations for the bracket. Two mounting feet on the bracket are used to mount the turn switch to the panel. The bracket is normally fastened to the frame with the mounting feet on either side of the spring combination. The bracket must be reversed for high pileups to prevent interference (between the pileup combinations and the mounting feet).

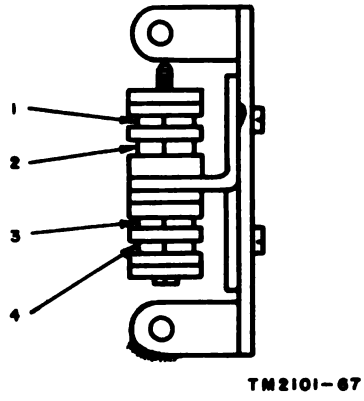


Figure 67. Turn switch, contact numbering.

144. Operation

Operation of the plunger (turned 90° clockwise) causes the plunger springs of the pileup to separate. This action causes the contacts of the plunger and contact springs to make or break.

145. Turn Switch Adjustments

Before performing any checks or adjustments, the switch and contacts should be cleaned.

a. Adjustment of Contact Alinement.

(1) *Checks.*

(*a*) See that the point of contact of each spring falls wholly within the boundary of the opposing contact.

(*b*) Gage the contact alinement by eye.

(*c*) Check the contact alinement for all positions of the switch.

(2) *Adjustment procedure.*

(*a*) Loosen the two spring assembly mounting screws of the pileup.

(*b*) Shift the springs as required.

(*c*) Tighten the screws securely after the adjustment is completed.

b. Adjustment of Plunger Action.

(1) *Checks.*

(*a*) Turn the plunger a few degrees clockwise from the unoperated position and release it. The plunger should spring back to the unoperated position.

(*b*) Operate the plunger to the operated position and tap it smartly several times. The switch should remain operated.

(*c*) Check to see that the setscrew in the side of the plunger is tightened securely.

(2) *Adjustment procedure.*

(*a*) Unscrew the retaining screw and remove the plunger.

(*b*) Use duckbill pliers or a spring adjuster to adjust the plunger springs.

(*c*) Bend both springs equally at the insulator end to decrease the separation between the springs so that the separation is less than the width of the rectangular cam.

(*d*) Replace the plunger. The plunger springs should separate slightly.

(*e*) Replace the retaining screw and tighten it securely.

c. Adjustment of Contact Separation (fig. 65).

(1) *Checks.*

(*a*) Check the contact separation between all pairs of normally open contacts.

(*b*) Operate the switch and check the contact separation between all pairs of contacts that break when the switch is operated.

(*c*) Gage the contact separation by eye. The separation between any pair of contacts should be not less than .010 inch.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to adjust the contact separation.

(*b*) Bend the spring slightly in the required direction, applying pressure a short distance behind the contacts.

d. Adjustment of Contact Follow (fig. 65).

(1) *Checks.*

(*a*) Check the follow of each making contact spring when the switch is operated.

(*b*) Check the follow of each making contact when the switch is released.

(*c*) Gage the follow by eye. The follow should be not less than .010 inch for each contact spring. This requirement does not apply to a contact spring backed up by a heavier spring acting as a stop spring.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to adjust the contact follow.

(*b*) Make the inner spring adjustments before proceeding with the outer spring adjustments.

(*c*) Bend the spring near the insulator end in the required direction.

e. Adjustment of Contact Sequence.

(1) *Checks.*

(*a*) Check to see that all contacts break before any contacts make, except for make-before-break combinations.

(*b*) For make-before-break combinations, check to see that all open con-

tacts make before the closed contacts break.

(*c*) See that the interval between make and break, except for make-before-break combination, is not less than .006 inch.

(*d*) Gage the interval between make and break by eye.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to correct the contact sequence and the make-break interval.

(*b*) Bend the spring slightly to achieve the required result.

f. Adjustment of Contact Pressure.

(1) *Checks.*

(*a*) Use a contact pressure gage to measure the contact pressure.

(*b*) Measure the contact pressure between all normally closed contacts.

(*c*) Operate the switch and check the contact pressure between all contacts that make when the switch is operated.

(*d*) The pressure between the make contacts must be at least 60 grams.

(2) *Adjustment procedures.*

(*a*) Use duckbill pliers or a spring adjuster to correct the contact pressure.

(*b*) Bend the spring near the insulator end in the required direction to increase the contact pressure.

146. Final Testing

After the checks and adjustments are completed, perform the final bench service test procedure (using a 24-volt buzzer with a self-contained battery).

a. Operate and release the switch several times to stabilize operation of the springs.

b. Operate the switch.

c. Momentarily touch the buzzer leads successively across the terminals of the make contacts. The buzzer should sound each time.

d. Release the switch.

e. Momentarily touch the buzzer leads successively across the terminals of the break contacts. The buzzer should sound each time.

Section X. PUSH SWITCH

147. Nomenclature and Function of Parts

Two models of push switches are provided. One model is shown in figure 68 and is described below. The other model is similar to the turn switch (fig. 66), except that the retaining screw on the side of the plunger is set into an axial slot in the collar of the frame instead of the transverse slot. The plunger then moves in the axial direction. The turn switch can be converted into a push switch, by relocating the retaining screw. The transverse slot is used for turn switches and the vertical slot for push switches. When used as a push switch, a conical area of the plunger instead of the rectangular cam spreads the plunger springs when the switch is operated.

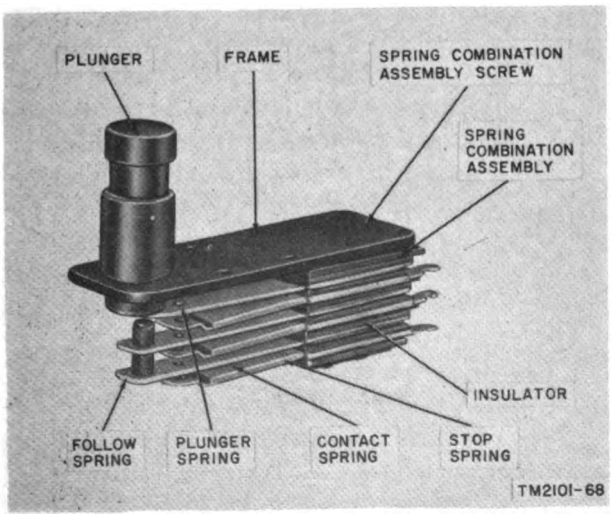


Figure 68. Push switch, typical.

a. Frame. The frame supports the various components of the switch and provides the means of fastening the switch to a panel. One end of the frame has two tapped holes for fastening the spring combination assembly. The other end is fitted with a barrel to accommodate the plunger.

b. Plunger. The plunger operates the spring combinations. One end is the pushbutton and

the other end presses against the plunger spring.

c. Spring Combination Assembly. The spring combination assembly (pileup) consists of plunger, follow contact and stop springs separated by insulators and fastened to the frame with two spring combination assembly mounting screws. The pileup uses various basic spring combinations to build up a specific switch combination. Contact springs are numbered as shown in figure 69. Three holes are provided for mounting the switch.

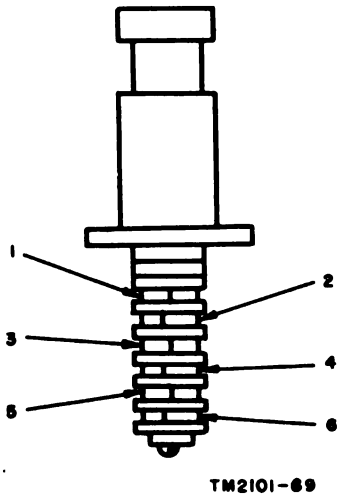


Figure 69. Push switch, contact numbering.

148. Push Switch Adjustments

Before performing any checks or adjustments, the switch and switch contacts should be cleaned.

a. Adjustment of Contact Alinement.

(1) *Checks.*

(*a*) Check to see that the point of contact of each spring falls wholly with the boundary of the opposing contact.

(*b*) Gage the contact alinement by eye.

(*c*) Check the contact alinement for all positions of the switch.

(2) *Adjustment procedure.*

(*a*) Loosen the two spring assembly mounting screws of the pileup.

(*b*) Shift the springs as required.

(*c*) Tighten the screws securely after the adjustment is completed.

b. Adjustment of Plunger Action.

(1) *Checks.*

(*a*) Check the plunger for end play. The plunger should contact the plunger spring at all times.

(*b*) Operate and release the plunger slowly. The plunger should be free from bind.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster for elimination of end play.

(*b*) Bend the plunger spring near the insulator end so that the plunger spring presses against the plunger.

c. Adjustment of Contact Separation.

(1) *Checks.*

(*a*) Check the contact separation between all pairs of normally open contacts.

(*b*) Operate the switch and check the contact separation between all pairs of contacts that break when the switch is operated.

(*c*) Gage the contact separation by eye. The separation between any pair of contacts should be not less than .010 inch.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to adjust the contact separation.

(*b*) Bend the spring slightly in the required direction, apply pressure a short distance behind the contacts.

d. Adjustment of Contact Follow (fig. 65).

(1) *Checks.*

(*a*) Check the follow of each making contact spring when the switch is operated.

(*b*) Check the follow of each making contact when the switch is released.

(*c*) Gage the follow by eye. The follow should be not less than .010 inch for each contact spring. This requirement does not apply to a contact spring backed up by a heavier spring acting as top spring.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to adjust the contact follow.

(*b*) Make the inner spring adjustments before proceeding with the outer spring adjustments.

(*c*) Bend the spring nearest the insulator end in the required direction.

e. Adjustment of Contact Sequence.

(1) *Checks.*

(*a*) Check to see that all contacts break before any contacts make, except for make-before-break combinations.

(*b*) For make-before-break combinations, see that all open contacts make before the closed contacts break.

(*c*) Check to see that the interval between make and break, except for make-before-break combinations, is not less than .006 inch.

(*d*) Gage the interval between make and break by eye.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to correct the contact sequence and make-break interval.

(*b*) Bend the spring slightly to achieve the required result.

f. Adjustment of Contact Pressure.

(1) *Checks.*

(*a*) Use a contact pressure gage to measure the contact pressure.

(*b*) Measure the contact pressure between normally closed contacts.

(*c*) Hold the switch in the operated position and check the contact pressure between all closed contacts.

(*d*) The pressure between the make contacts must be at least 60 grams.

(2) *Adjustment procedure.*

(*a*) Use duckbill pliers or a spring adjuster to correct the contact pressure.

(*b*) Bend the spring near the insulator end in the required direction to increase the contact pressure.

149. Final Testing

After the checks and adjustments are completed, perform the final bench service test procedure (using a 24-volt buzzer with a self-contained battery).

a. Momentarily touch the buzzer leads successively across the terminals of the normally closed contacts. The buzzer should sound each time.

b. Connect the buzzer leads across the terminals of a set of normally open contacts and operate the switch. The buzzer should sound.

c. Repeat *b* above until all normally open contacts have been tested.

d. Disconnect the buzzer leads.

CHAPTER 5

DIALS, PEG COUNT METER, JACKS, PLUGS, AND CORDS

Section I. TELEPHONE DIAL

150. Names and Function of Assemblies and Parts

The assemblies and parts of the telephone dial are discussed below. Each assembly and part is described, its function noted, and its location specified and illustrated. To orient the dial (front), place it face up with the numbers displayed in the fingerholes and the finger stop at the lower right. For rear orientation, turn the dial over with the terminal screws at the top.

a. Station Number Card (fig. 70). The station number card is in the center of the dial, under a transparent card holder, which fastens the station number card within the recess of the finger plate.

b. Finger Plate (fig. 70). The finger plate is above the number plate. It has 10 fingerholes which display the digits on the number plate. The finger plate is rotated in a clockwise direction in order to obtain the required number of dial pulses.

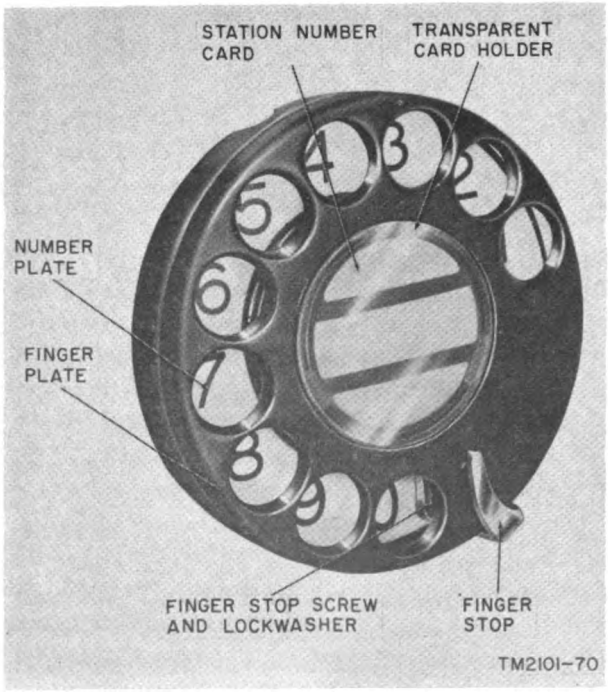


Figure 70. Dial, front view.

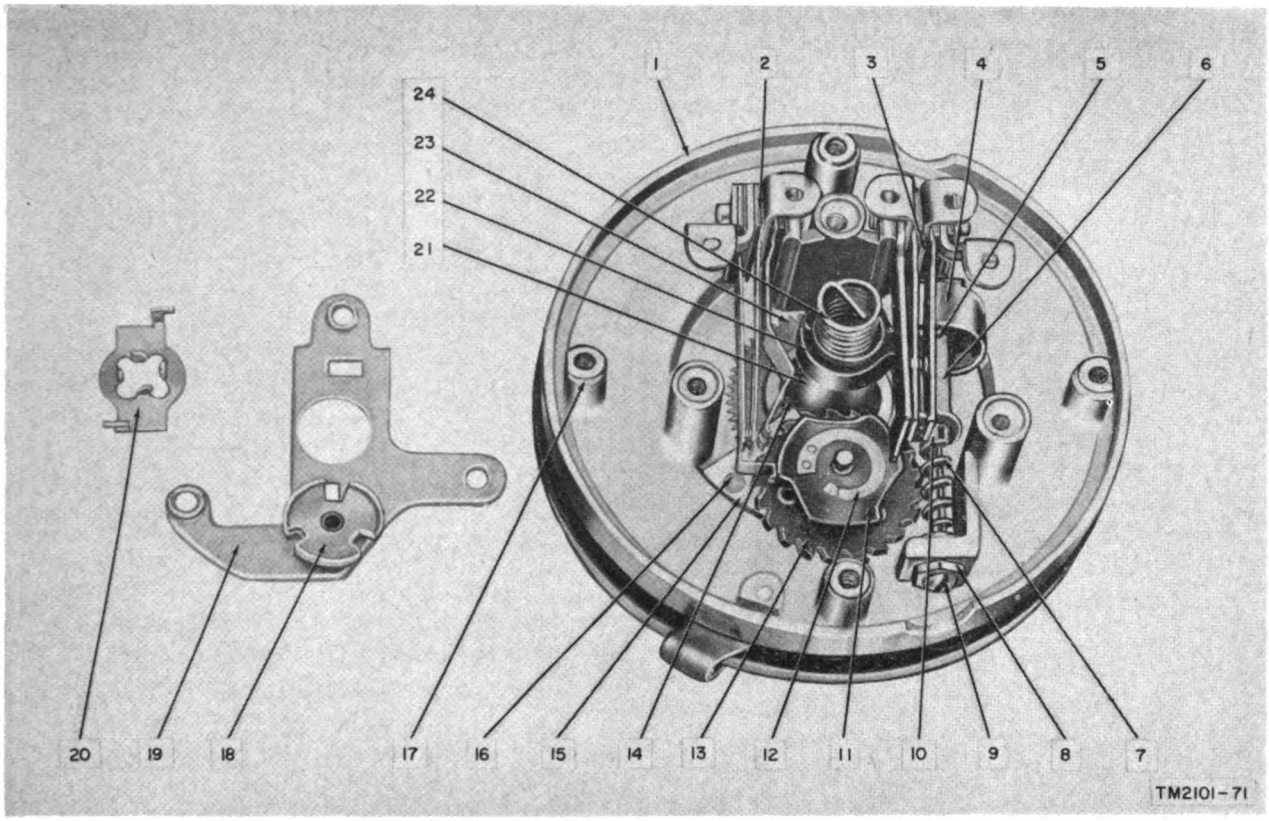
c. Finger Stop (fig. 70). The finger stop is at the bottom right of the dial. It is fastened to the number plate and front casting assembly by a finger stop screw and lockwasher. The finger stop serves as a forward stop for the finger plate.

d. Number Plate (fig. 70). The number plate is directly below the finger plate, and contains the digits 1 to 0 in a counterclockwise order around the number plate.

e. Internal Stop (fig. 71). The internal stop (15) is fastened on the rear of the front casting assembly (1), above the finger stop, by two internal stop screws (16). The internal stop prevents the finger plate from revolving too far in either direction. The internal stop stud (14), on the power shaft (21), strikes the internal stop when the finger plate has made 1 revolution in either direction.

f. Front Casting Assembly (fig. 71). The front casting assembly (1) is above the number plate. The assembly is comprised of two bearings and seven raised bosses (17) to provide a mounting for the pulse spring assembly (2), bridge and bearing assembly (19), shunt spring assembly (3), governor cup (4), tail bearing (9), pinion shaft assembly (13), internal stop (15) and dust cover (1, fig. 72).

g. Tail Bearing (fig. 71). The tail bearing (9) consists of a threaded bolt which is slotted at one end and indented at the other. It is fastened to a mounting hole in the front casting assembly (1) by the tail bearing nut (8). The tail bearing provides a seat for the lower end of the worm (7) and determines the amount of end play of the wormshaft assembly (10).



1 Front casting assembly
2 Pulse spring assembly
3 Shunt spring assembly
4 Governor cup
5 Fly bales
6 Wings
7 Worm
8 Tail bearing nut
9 Tail bearing
10 Worm shaft assembly
11 Pulse cam
12 Pulse cam spring
13 Pinion shaft assembly
14 Internal stop stud
15 Internal stop
16 Internal stop screw (2, 3–48 x ⅛ inch)
17 Bosses (7)
18 Pulse cam stop
19 Bridge and bearing assembly
20 Anchor
21 Power shaft
22 Combination cam
23 Gear wheel
24 Power shaft spring

Figure 71. Telephone dial, rear view (bridge removed).

h. Wormshaft Assembly (fig. 71). The wormshaft assembly (10) is fastened between the governor cup bearing and the tail bearing (9). The worm shaft assembly is comprised of a worm (7), two wings (6), and two fly bales (5). When the finger plate is released, the driving mechanism rotates the worm wheel which, in turn, rotates the fly bales within the governor cup (4). The friction produced by fly bales rotating against the inner surface of the governor cup retards the worm (7), thus regulating the pulse speed of the dial.

i. Power Shaft Assembly (fig. 71). The power shaft assembly is in the center of the dial and is fastened through the front casting assembly (1) to the finger plate. The power shaft consists of the parts listed in (1) through (4) below.

(1) *Power shaft spring.* The power shaft spring (24) is a helical-type spring inclosed within the power shaft (21). The top end of the spring is secured to the anchor (20), and the bottom end is permanently fastened within the power shaft. The power spring is tensioned by the anchor which is rotated 1½ turns. When the power shaft assembly is rotated by the finger plate, additional energy is stored in the power shaft spring.

(2) *Combination cam.* The combination cam (22) is fastened to the power shaft below the bridge and bearing assembly (19) and revolves with the power shaft. The combination cam has two studs, one on each side of the power shaft, at different levels. When the dial is normal, one of the studs positions the shunt spring assembly (3) while the other stud positions the pulse spring assembly (2). When the finger plate is off normal, the combination cam studs release the pulse and shunt springs.

(3) *Internal stop stud.* The internal stop stud (14) is located parallel to the shaft and mounted on the gear wheel (23). It prevents the shaft from making more than 1 revolution in either direction.

(4) *Gear wheel.* The gear wheel (23) is fastened to the shaft above the power shaft bearing in the front casting assembly (1). The gear wheel is equipped with 75 teeth which mesh with 15 teeth of the pinion gear to transfer power stored in the power shaft spring (24) to the pinion shaft assembly (13).

j. Pinion Shaft Assembly (fig. 71). The pinion shaft assembly (13) is between the bridge and bearing assembly (19) and the front casting assembly (1). The pinion shaft assembly is driven by the gear wheel (23) which is part of the power shaft assembly. The pinion shaft worm wheel drives the worm (7) of the worm-shaft assembly (10) which regulates the speed of the dial pulses. The pulse cam (11), located on the shaft, rides on a notched bearing (pulse cam stop).

k. Pulse cam (fig. 71). The pulse cam (11) is located on the shaft of the pinion shaft assembly (13). The front pulse cam spring (12) rides on the notched bearing of the pinion shaft assembly. When the pinion shaft assembly is rotated in a counterclockwise direction the pulse cam spring which is riveted to the pulse cam moves in and out of the bearing notches; this action provides an audible indication of the digit dialed. When the pinion shaft assembly is returned to the normal position (clockwise) against the pulse cam stop (18), the spring holds the cam in a position that permits it to rotate against the main pulse spring (21, fig. 72). This action provides the dial pulses which corresponds to the digit dialed. The rear pulse cam spring (on the rear side of the pulse cam), holds the cam when the pinion shaft assembly is rotated off-normal, and provides an audible indication when returned to the normal position.

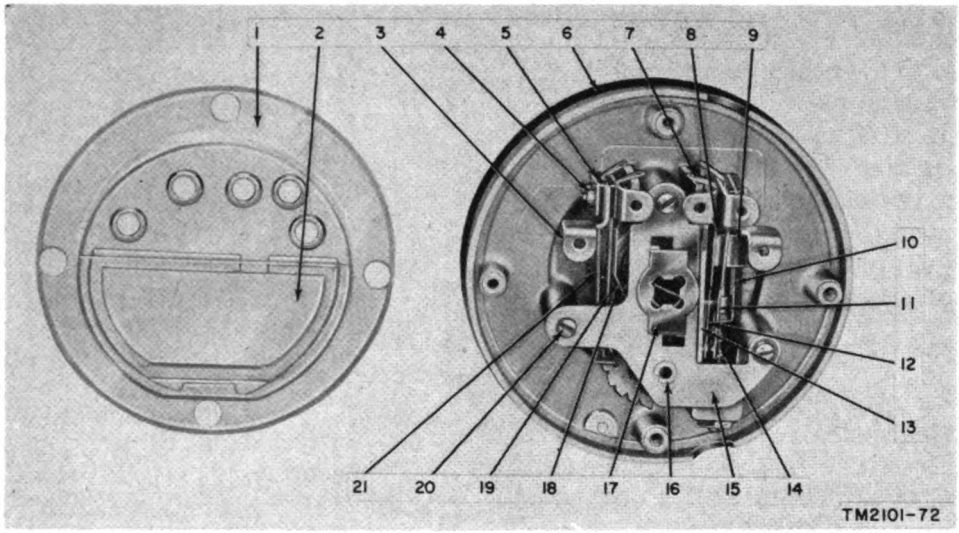
l. Bridge and Bearing Assembly (fig. 72). The bridge and bearing assembly (15), in the center of the front casting assembly (6), is fastened to three threaded bosses by three bridge holding screws (20). The bridge and bearing assembly mounts the anchor (17) in the rear side and provides a bearing surface for the movement of the pulse cam spring (12, fig. 71) in the front side.

m. Governor Cup (fig. 72). The governor cup (9), located below the shunt spring assembly (7), is fastened to a mounting hole of the front casting assembly (6) by the governor cup nut (8). The inner surface of the governor cup provides a retarding action to the rotating fly bales (5, fig. 71) fastened to the end of the wings (10, fig. 72). The retarding action of the fly bales is transferred to the worm (14) to regulate the return speed of the finger plate (fig. 70).

n. Pulse Spring Assembly (fig. 72). The pulse spring assembly (5) to the left of the bridge and bearing assembly (15) is fastened to a mounting boss on the front casting assembly (6) by two shunt and pulse spring assembly holding screws (4). The main pulse spring (21) of the pulse spring assembly is operated by the pulse cam. The pulse spring assembly consists of the parts listed in (1) through (3) below.

(1) *Main pulse spring.* The main pulse spring (21) has an angled tip and a flat contact. The angled tip is engaged by the pulse cam; this causes the contact to break-and-make with the contact of the middle pulse spring (19).

(2) *Middle pulse spring.* The middle pulse spring (19) has a rounded contact which breaks and makes with the main pulse spring (21). It rides on the heavy stop spring (18) and follows it in the operate and nonoperate positions.



1 Dust cover
2 Trap door
3 Terminals (5)
4 Shunt and pulse spring assembly holding screw (4, 3–48 x 1/16 inch)
5 Pulse spring assembly
6 Front casting assembly
7 Shunt spring assembly
8 Governor cup nut
9 Governor cup
10 Wings
11 Outside operating shunt spring
12 Middle operating shunt spring
13 Shunt stop spring
14 Worm
15 Bridge and bearing assembly
16 Upper pinion shaft bearing
17 Anchor
18 Heavy stop spring
19 Middle pulse spring
20 Bridge holding screw (3, 4–40 x 3/32 inch)
21 Main pulse spring

Figure 72. Telephone dial, rear view (dust cover removed).

(3) *Heavy stop spring.* The heavy stop spring (18) rides on the combination cam. In the off-normal position, the combination cam operates the heavy stop spring. When operated, the main pulse spring (21) is placed in a position where it can be operated by the pulse cam. When the combination cam is returned to the normal position, the combination cam raises the spring to a nonoperate position. This action places the spring in a position that prevents further pulse operation by the pulse cam.

o. Shunt Spring Assembly (fig. 72). The shunt spring assembly (7) at the right of the bridge and bearing assembly (15) is fastened by two shunt and pulse spring assembly holding screws (4) to the mounting boss on the front casting assembly (6). The shunt springs assembly shunts the receiver out of the circuit during the dialing operation. The shunt spring assembly consists of the parts listed in (1) through (3) below.

(1) *Outside operating shunt spring.* The outside operating shunt spring (11) has an extension stud at its midsection which passes through a hole in the middle operating shunt spring (12). In the off-normal position, the extension stud which rides on the combination cam operates the shunt springs to their make position. In the normal position, the springs are at the break position.

(2) *Middle operating shunt spring.* The middle operating shunt spring (12) has a flat contact which makes with the outside shunt spring and shunt stop spring in the off-normal position and breaks in the normal position.

(3) *Shunt stop spring.* The shunt stop spring (13) is a heavy flat spring with a flat contact. When the combination cam releases the extension stud, the outside operating shunt spring makes with the middle operating shunt spring (12).

p. Dust Cover (fig. 72). The dust cover (1) completely incloses the telephone dial mechanism and is fastened to the bridge and bearing assembly (15) by five terminal screws. The four holes around the rim of the cover fit over the bosses of the front casting assembly (6). The dust cover protects the dial mechanism from dust, dirt, grease, or other injurious matter. A snap-on trap door (2) permits quick access to the dial mechanism for adjustment or repair.

151. Operation

The dial operates in such a manner that when the finger plate is rotated off-normal and released, dial pulses (interruptions in current) are produced. The mechanical operations of the dial are described below.

a. Off-Normal (Clockwise).

(1) When the finger plate is rotated to the finger stop, the power shaft rotates clockwise and tensions the power shaft spring. The combination cam positions the pulse spring close to the shorting arms of the pulse cam, and also allows the shunt springs to close which shunts the receiver.

(2) The gear wheel, integral with the power shaft, drives the pinion gear of the pinion shaft assembly. The front pulse cam spring rotates over the notches in the front pulse cam stop and provides an audible indication corresponding to the digit dialed. Simultaneously, the rear pulse cam spring engages the rear pulse cam stop and holds the pulse cam in the shorting (nonoperating) position.

b. Off-Normal (Counterclockwise).

(1) The power shaft spring is released and the gear wheel of the power shaft assembly drives the pinion gear clockwise.

(2) The rear pulse cam spring rotates over the rear pulse cam stop; this action provides an audible indication which corresponds to the digit dialed. The front pulse cam spring engages the front pulse cam stop and simultaneously drives the pulse cam and the worm wheel.

(3) The worm wheel drives the wormshaft assembly which, in turn, causes the fly bales to rotate against the inner surface of the governor cup. This action regulates the speed of the pulse cam.

(4) The pulse cam alternately engages and disengages the main pulse spring, which makes and breaks the middle pulse spring. This action provides the dial pulses which correspond to the digit dialed.

c. Normal.

(1) The internal stop stud engages the internal stop to prevent any further rotation of the power shaft.

(2) The combination cam breaks the contacts of the shunt springs to remove the shunt from the receiver. Simultaneously, the combination cam engages the main pulse spring, which causes the pulse spring to be moved to a nonoperate position to prevent further pulsing.

152. Disassembly (fig. 73)

a. Number Dial Assembly.

(1) Place the dial face up and press with a thin screwdriver blade on the edge of the card holder between digits 3 and 4, 7 and 8, and digit 1 and the finger stop and lift out the transparent card holder (1).

(2) Lift out the station number card (2).

(3) Use the flat-jawed pliers to remove the power shaft nut and washer (3 and 4).

(4) Remove the shaft retainer spring (5).

(5) Remove the finger plate (6).

(6) Use a Phillips screwdriver to remove the finger stop screw and lockwasher (7 and 8).

(7) Lift out the finger stop (9).

(8) Disengage the number plate (10) from the front casting assembly (48).

(9) Remove the two internal stop screws (11); then remove the internal stop (12) from the rear of the front casting assembly (48).

(10) Place the partly disassembled dial face down and remove five terminal screws (13) from the dust cover (14).

(11) Lift out the trap door (15).

(12) Remove the dust cover from the front casting assembly bosses.

b. Power Shaft Assembly.

(1) Insert a small screwdriver blade into the anchor (16) and turn it clockwise to disengage the anchor tabs from the slots in the bridge and bearing assembly (18).

(2) Unhook the anchor from the power shaft assembly (21).

(3) Unscrew three bridge holding screws (17) from the bridge and bearing assembly (18).

(4) Lift out the pulse cam (19).

(5) Remove the pinion shaft assembly (20).

(6) Remove the power shaft assembly (21).

c. Governor Cup and Wormshaft Assembly.

(1) Loosen the tail bearing nut (22) and unscrew the tail bearing (23).

(2) Withdraw the wormshaft assembly (24) from the governor cup (26).

(3) Remove the governor cup (26) by removing the governor cup nut (25).

d. Shunt Spring Assembly.

(1) Unscrew the two shunt spring assembly holding screws from the front casting assembly (48).

(2) Remove the shunt spring assembly (27) by removing the two spring assembly holding screws (28), screw plate (30), four insulating spacers (31), terminal (32), outside operating shunt spring (33), terminal (34), middle operating shunt spring (35), shunt stop spring (36) and terminal (37) from the two insulating bushings (29).

e. Pulse Spring Assembly.

(1) Unscrew the two pulse spring assembly holding screws from the front casting assembly (48).

(2) Remove the pulse spring assembly (38) by removing the two pulse spring assembly holding screws (39), screw plate (41), four insulating spacers (42), main contact pulse spring (43), terminal (44), middle contact pulse spring (45), terminal (46), and heavy stop spring (47) from the two insulating bushings (40).

153. Reassembly
(fig. 73)

The reassembly instructions provide for the rough adjustment of all assemblies and parts. Specific adjustment instructions are given in paragraphs 154 through 159 and must be performed before the dial can be put in service.

a. Shunt Spring Assembly.

(1) Mount the two insulating bushings (29) on the two shunt spring assembly holding screws (28).

(2) Slide the screw plate (30), insulating spacer (31), and terminal (32) on the insulating bushing.

(3) Press the outside operating shunt spring (33) firmly on the insulating bushings.

(4) Add an insulating spacer (31), terminal (34), middle operating shunt spring (35), and insulating spacer (31) on the insulating bushings.

(5) Press the shunt stop spring (36) on the insulating bushings.

(6) Mount a terminal (37) firmly against the shunt stop spring.

(7) Press an insulating spacer (31) on the insulating bushings.

(8) Hold the completed assembly together and fasten the shunt spring assembly (27) to the right mounting boss of the front casting assembly (48) with the two shunt spring assembly holding screws.

b. Pulse Spring Assembly.

(1) Mount the two insulating bushings (40) on the two pulse spring assembly holding screws (39).

(2) Place the screw plate (41), insulating spacer (42), main contact pulse spring (43), terminal (44), insulating spacer (42), middle pulse spring (45), terminal (46), and insulating spacer (42) on the insulating bushings (40).

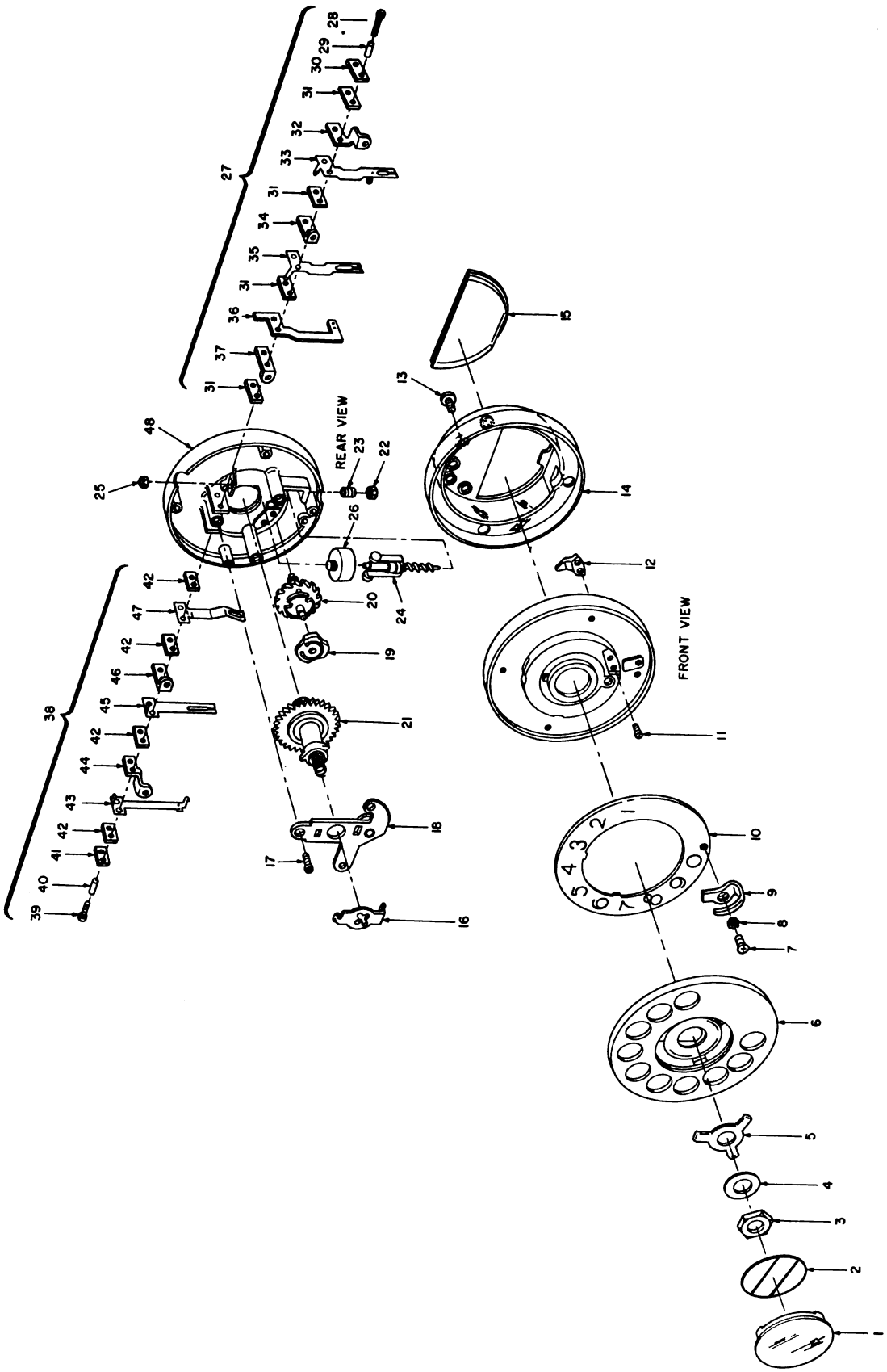


Figure 78. Telephone dial, exploded view.

1 Transparent card holder
2 Station number card
3 Power shaft nut
4 Power shaft washer
5 Shaft retainer spring
6 Finger plate
7 Finger stop screw
8 Finger stop lock washer
9 Finger stop
10 Number plate
11 Internal stop screw (2, 3/48 x 1/8 inch)
12 Internal stop
13 Terminal screw (5, 4–40 x 5/32 inch)
14 Dust cover
15 Trap door
16 Anchor
17 Bridge holding screw (3, 4–40 x 5/32 inch)
18 Bridge and bearing assembly
19 Pulse cam
20 Pinion shaft assembly
21 Power shaft assembly
22 Tail bearing nut
23 Tail bearing
24 Worm shaft assembly
25 Governor cup nut
26 Governor cup
27 Shunt spring assembly
28 Shunt spring assembly holding screw (2, 3–48 x 7/16 inch)
29 Insulating bushing (2)
30 Screw plate
31 Insulating spacer (4)
32 Terminal
33 Outside operating shunt spring
34 Terminal
35 Middle operating shunt spring
36 Shunt stop spring
37 Terminal
38 Pulse spring assembly
39 Pulse spring assembly holding screw (2, 3–48 x 7/16 inch)
40 Insulating bushing (2)
41 Screw plate
42 Insulating spacer (4)
43 Main pulse spring
44 Terminal
45 Middle pulse spring
46 Terminal
47 Heavy stop spring
48 Front casting assembly

Figure 73—Continued.

(3) Press the heavy stop spring (47) firmly on insulating bushings; then add another insulating spacer (42).
(4) Hold the assembly together and fasten the pulse spring assembly (38) to the left mounting boss of the front casting assembly (48) with the two pulse spring assembly holding screws.

c. Governor Cup and Wormshaft Assembly.
(1) Mount the governor cup (26) into the mounting hole in the front casting assembly (48), and fasten it with the governor cup nut (25).
(2) Insert the tail of the wormshaft assembly (24) through the tail bearing mounting hole until the fly bales can be moved into the governor cup.
(3) Seat the end of the wormshaft into the governor cup bearing.
(4) Turn the tail bearing (23) into the tail bearing mounting boss on the wormshaft assembly.
(5) Allow an .010 inch end play (judged by eye) and fasten the tail bearing with the tail bearing nut (22).

d. Power Shaft and Pinion Shaft Assemblies.
(1) Insert the power shaft assembly (21) into the front bearing of the front casting assembly (48).
(2) Install the internal stop (12) over the gear wheel to reach the stop stud on the power shaft assembly.
(3) Insert and fasten the internal stop to the front casting assembly with the two internal stop screws (11).
(4) Insert the pinion shaft assembly (20) into the bearing on the front casting assembly, and mesh the gear teeth with those of the gear wheel of the power shaft assembly.
(5) Place the pulse cam (19) on the pinion shaft.

Note. Be sure that the pulse cam turns only counterclockwise. If the cam turns in either direction, remove it from the pinion shaft and turn it over.

e. Bridge and Bearing Assembly.
(1) Install the bridge and bearing assembly (18) by fitting the pinion shaft into the pinion bearing. Observe that the power spring extends through the power shaft bearing, and that the three screw holes line up with the boss

mountings in the front casting assembly (48).

(2) Fasten the bridge and bearing assembly to the bosses with the three bridge holding screws (17).

(3) Thread the extended end of the power shaft spring through the two hooks on the rear of the anchor (16).

(4) Insert a screwdriver blade into the anchor and turn it against the spring tension (counterclockwise) 1½ turns.

(5) Lock the anchor tabs into the two slots on the bridge.

f. Dust Cover.

(1) Fit the dust cover (14) into four mounting bosses around the rim of the front casting assembly (48).

(2) Line up the five screw holes with the five terminals of the pulse and shunt spring assemblies (27 and 38).

(3) Replace five terminal screws (13).

(4) Snap on the dust cover trap door (15).

g. Number Dial Assembly.

(1) Position the number plate (10) on the front casting assembly (48).

(2) Place the finger stop (9) over the mounting holes and fasten it with the two finger stop screws and lockwashers (7 and 8).

(3) Replace the finger plate (6). Be sure that all digits are displayed in the fingerholes.

(4) Place the shaft retainer spring (5) into the three slots in the finger plate by seating the ends of the arms into receptacles located between digits 3 and 4, 7 and 8, and digit 1 and the finger stop.

(5) Fasten the power shaft washer (4) over the end of the power shaft assembly (21).

(6) Fasten the power shaft nut (3) on the threaded end of the power shaft assembly.

(7) Press the station number card (2) into place.

(8) Replace the transparent card holder (1) by pressing the tips into the three receptacles of the finger plate.

154. Adjustments

Before attempting to adjust the dial, check for signs of excessive wear or damage. If the dial mechanism appears to be in good working condition, proceed with the adjustments below. If an adjustment of a particular part affects an associated part or assembly, check both parts before proceeding any further. Unless otherwise specified, all adjustments should be made to the closest tolerance to obtain optimum performance of the dial. After the adjustment procedures have been completed, perform a final test on the dial.

155. Adjustment of Finger Plate

a. Checks.

(1) Check the finger plate for binding against the finger stop.

(2) Check for a bent plate.

b. Adjustment Procedure.

(1) If the finger stop is binding against the finger plate, adjust the finger stop with flat-jawed pliers until the finger plate is clear.

(2) Use a thickness gage to measure the clearance between the finger plate and the underside of the finger stop. The clearance should be .025 inch at all points when the digit 0 is dialed.

(3) If the finger plate is bent or damaged and cannot be adjusted to within the specified limits, replace the part.

156. Adjustment of Power Spring Tension (fig. 74)

a. Checks.

(1) Check to see that the power shaft spring has been rotated 1½ turns of the anchor.

(2) Check to see that the anchor tabs are firmly seated in the mounting slots.

b. Adjustment Procedure.

(1) Remove the trapdoor of the dust cover.

(2) Insert a screwdriver blade into the anchor and turn it clockwise until the anchor tabs are disengaged from the slots.

(3) When the power shaft spring is free, reseat the anchor with the proper

amount of spring tension by turning the screwdriver 1½ turns clockwise.

(4) Fasten the anchor tabs into the two slots provided on the bridge and bearing assembly.

(5) If the power spring is broken, replace the power shaft assembly.

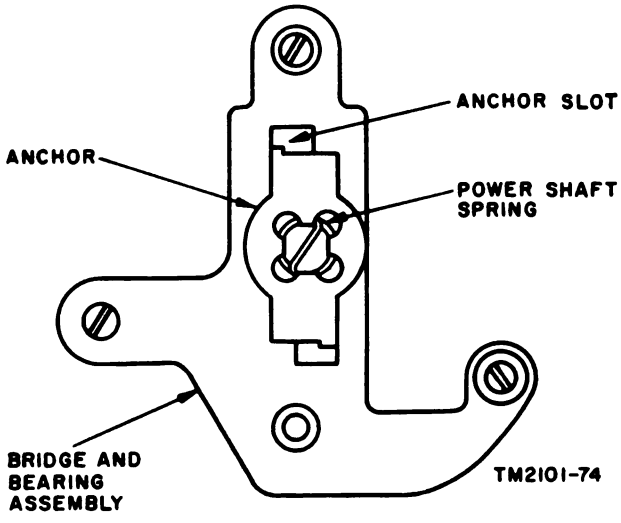


Figure 74. Power spring adjustment.

157. Adjustment of Pulse Spring Assembly (fig. 75)

a. Checks. Check to see that—

(1) The middle pulse spring (when not engaged with the pulse cam) rests firmly against the heavy stop spring with a tension of 28 to 33 grams.

(2) The main pulse spring rests firmly against the contact of the middle pulse spring with a tension of 28 to 33 grams, with the finger plate off normal and the top of the main pulse spring opposite the low side of the pulse cam.

(3) The distance between the springs (the distance between the main and middle pulse springs, and between the middle pulse spring and the heavy stop spring) remains relatively the same when the finger plate is operated in a clockwise direction to the finger stop.

b. Adjustment Procedure.

(1) Use a thickness gage to determine the proper spring contact spacing, and adjust the springs as required with long-nosed pliers.

(2) Apply a gram gage to the main pulse spring, and continue to adjust for the correct contact spacing and spring pressure.

(3) Adjust the heavy stop spring with long-nosed pliers and judge (by eye) the correct position of the pulse spring assembly (*a*(3) above).

(4) If the above adjustments cannot be made, replace the pulse springs assembly.

158. Adjustment of Shunt Spring Assembly (fig. 75)

a. Checks. Check to see that—

(1) The shunt spring contacts are .015 inch apart when the finger plate is normal.

(2) The shunt spring contacts close with a pressure of 25 to 35 grams when the finger plate is off-normal.

b. Adjustment Procedure.

(1) With the finger plate off normal, measure the spring contact spacing with a thickness gage.

(2) Bend the springs with long-nosed pliers to obtain the proper spacing.

(3) Measure the spring pressure with a gram gage.

(4) If the proper spring contact spacing and spring pressure cannot be obtained, replace the shunt spring assembly.

159. Adjustment of Governor Assembly (fig. 76)

a. Checks. Check to see that—

(1) The normal operating speed of the dial is approximately 10 pulses per second.

(2) The wormshaft assembly is completely free and is running without drag.

(3) The end play of the worm does not exceed .010 inch.

b. Adjustment Procedure.

(1) Time the dial pulsing by dialing the digit 0. The finger plate should return to normal in approximateyl 1 second.

(2) If the finger plate returns too rapidly, bend the wings of the wormshaft assembly farther apart; if the finger plate returns too slowly, press the wings together.

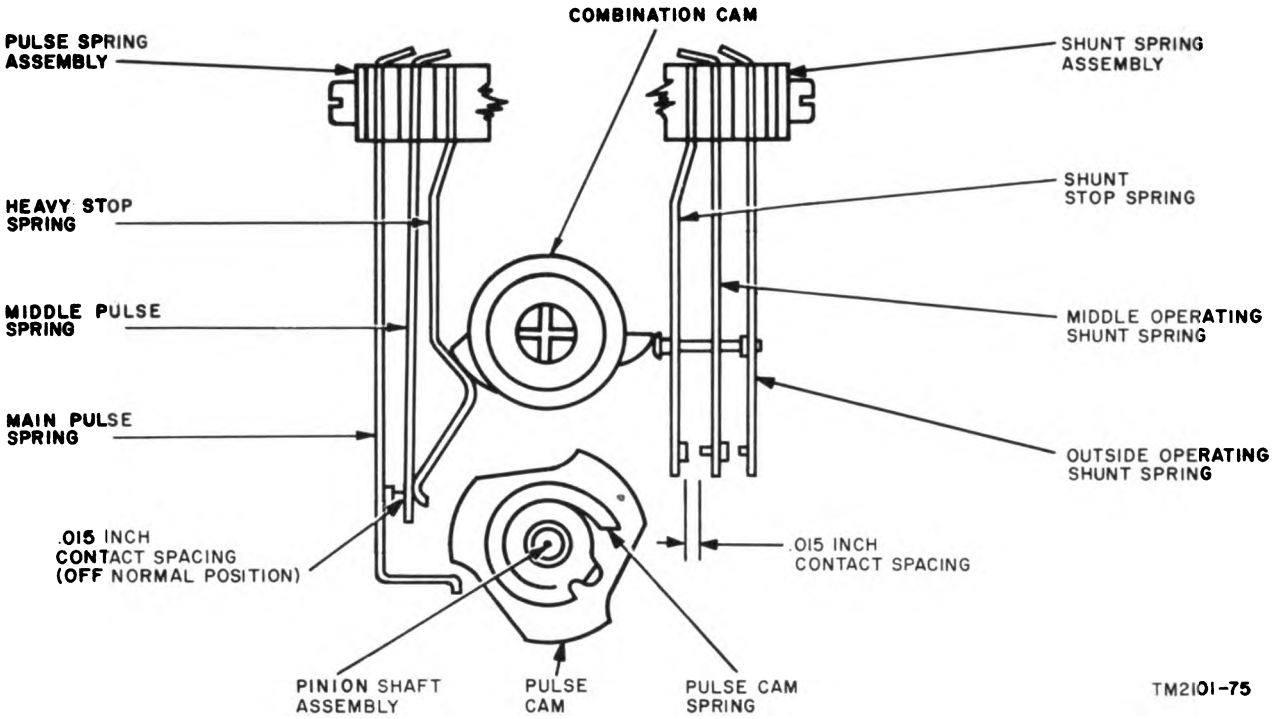


Figure 75. Pulse and shunt spring assembly adjustments (normal position).

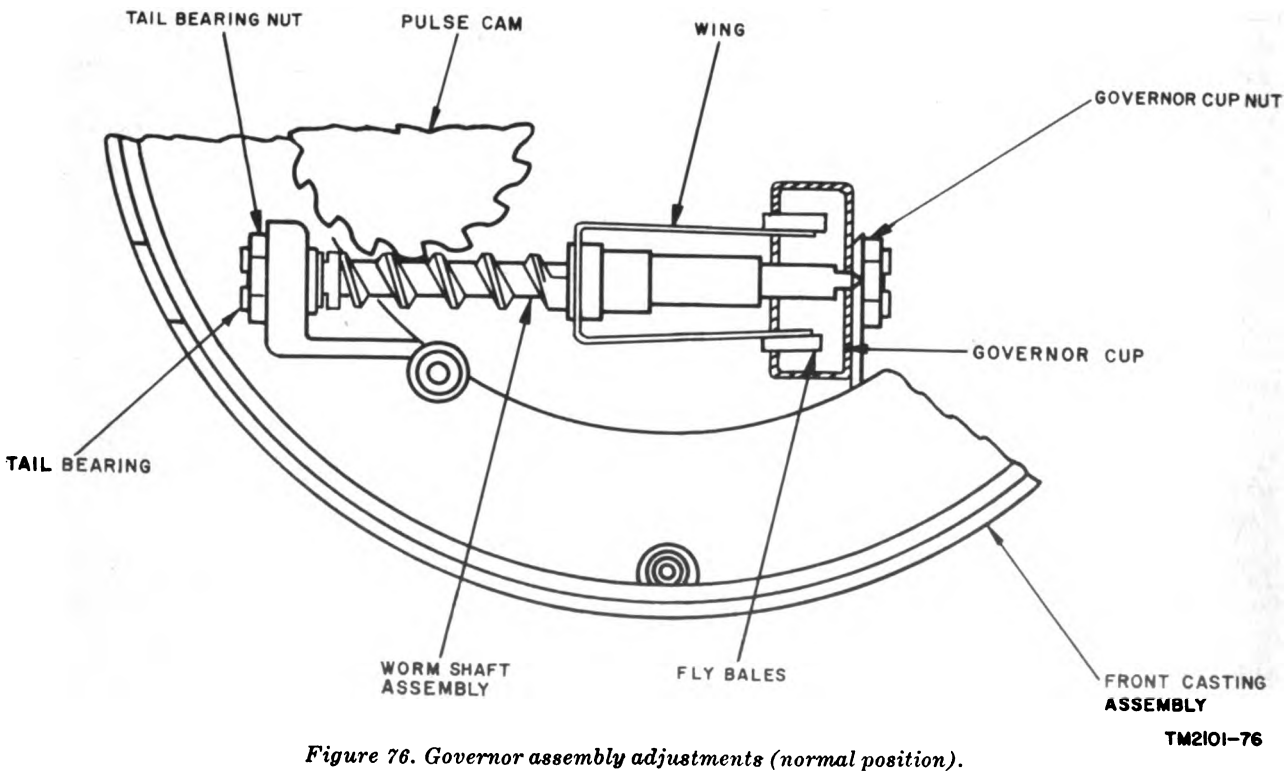


Figure 76. Governor assembly adjustments (normal position).

(3) Determine if the wormshaft assembly turns freely. If not, follow the procedure listed below.

(*a*) Adjust the end play of the wormshaft assembly by loosening the tail bearing nut and adjusting the tail bearing.

(*b*) Determine (by eye) the amount of end play required.

(*c*) Make the proper adjustment, then tighten the tail bearing nut firmly.

(4) If the wormshaft assembly cannot be adjusted to provide steady dial speed, replace the wormshaft assembly.

160. Final Testing

Final testing of the dial should be performed after repair, replacement, or adjustment procedures have been completed. Included in the final testing of the unit are a pulse speed test and a percent make test, both of which can be performed through the use of the pulse speed and percent make test set. Instructions for operating the test set are contained in TM 11–2120. To determine whether the dial is meeting minimum operating standards, separate bench and in service (operational) tests should be made. In each case, the results obtained must correspond with the specified pulse speed and percent make values outlined in TM 11–2120.

Section II. PEG COUNT METER

161. Names and Function of Parts

To orient the peg count meter, vertically position the part with the male terminals at the top and the digit drums at the bottom. This will locate the escapement gear on the right side.

a. Frame Assembly (fig. 77). The frame assembly is a mounting for the principal parts and assemblies of the peg count meter, including: four drums (unit, tens, hundreds, and thousands), armature assembly and escapement gear, coil assembly, and mounting base and plug.

b. Mounting Base and Plug (fig. 78). The mounting base and plug (1) is fastened to the coil assembly core (against the right-angle arm of the frame assembly) by the retaining nut (2) and spacer (3). The terminals at the bottom of the mounting base provide solder connections to the coil assembly terminations. The plug terminals (male) are riveted into the base and provide external connection to the mating receptacle.

c. Coil Assembly (fig. 78). The coil assembly (19) is within the frame assembly (18) and is fastened by the retaining nut (2) that also retains the mounting base and plug (1). When energized, the coil assembly attracts the armature assembly (15) to its coil core.

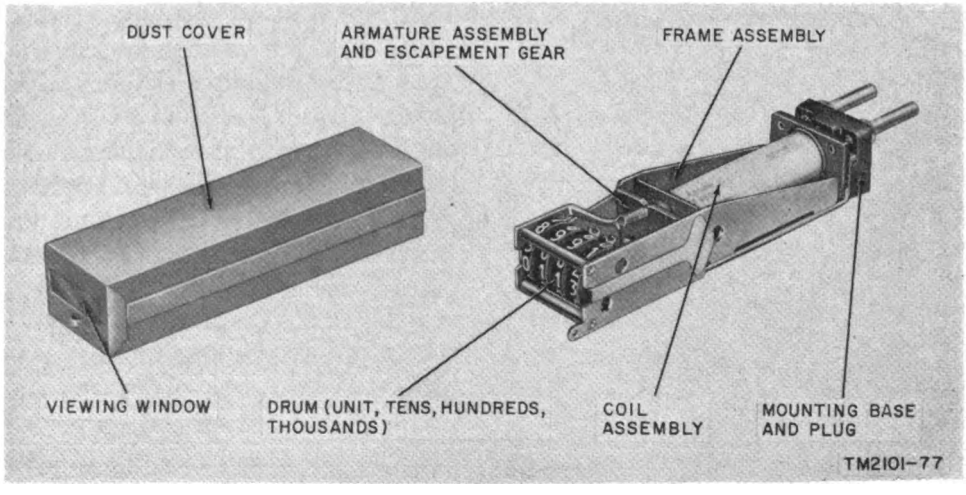
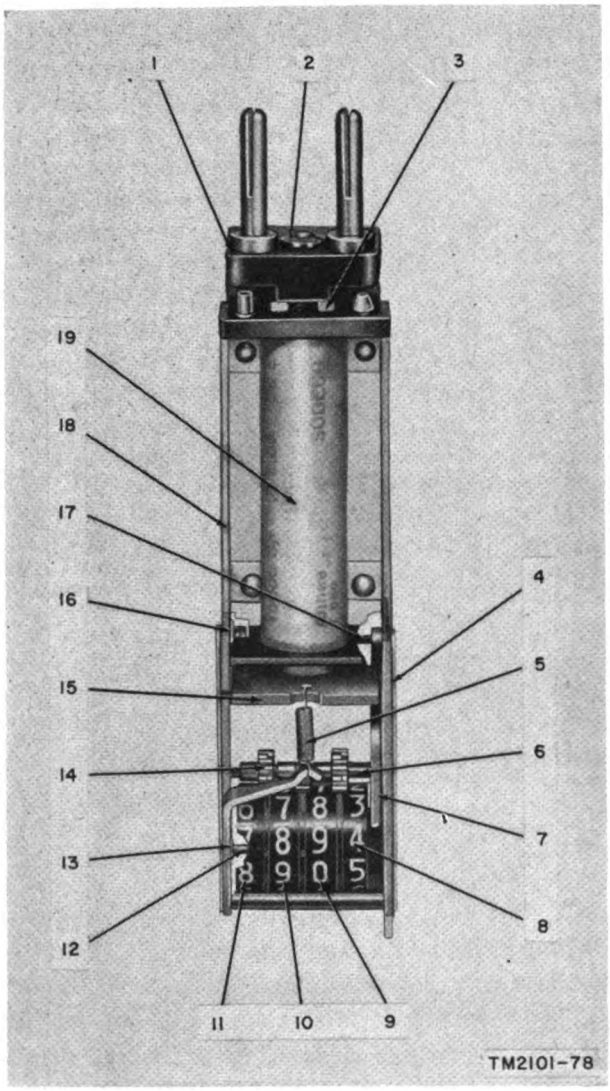


Figure 77. Peg count meter (dust cover removed).



1 Mounting base and plug
2 Retaining nut
3 Spacer
4 Retaining strip (2)
5 Armature spring
6 Switch wheel spindle
7 Escapement gear
8 Unit drum
9 Tens drum
10 Hundreds drum
11 Thousands drum
12 Drum spindle
13 Drum spindle washer (2)
14 Switch wheel (3)
15 Armature assembly
16 Armature assembly spindle
17 Armature assembly spindle washer (2)
18 Frame assembly
19 Coil assembly

Figure 78. Peg count meter, top view.

d. Armature Assembly and Escapement Gear (fig. 78). The armature assembly and escapement gear (7 and 15) are below the coil assembly (19) and are fastened between the sides of the frame assembly (18) by the armature assembly spindle (16) and two armature assembly spindle washers (17). When the coil assembly is energized, the armature assembly is attracted to the coil core and the associated escapement gear (riveted to the armature assembly) engages the unit drum gear. The upstroke of the armature assembly rotates the unit drum one-half position clockwise and the downstroke completes the movement.

e. Armature Spring (fig. 78). The armature spring (5) is fastened between the frame assembly tongue and the mounting hole in the armature assembly (15). When the armature assembly is operated, the armature spring is tensioned. When released, the armature spring returns the armature assembly to its normal (unoperated) position.

f. Unit Drum (fig. 78). The unit drum (8) is at the bottom of the frame assembly (18) and is fastened in place by the drum spindle (12) and two drum spindle washers (13). The unit drum gear (on the right side) receives the escapement gear, rotating the unit drum in a clockwise direction. On the left side of the unit drum are two teeth that mate with like teeth on the tens drum. When the driver tooth on the switch wheel engages the mated teeth, it rotates the unit drum to position zero and the tens drum to the next sequential digit.

g. Tens Drum (fig. 78). The tens drum (9) is interchangeable with the hundreds drum and is located at the bottom of the frame assembly (18) to the left of the unit drum. The tens drum is fastened to the frame assembly in the same manner as the unit drum. On the right of the tens drum are 20 teeth. When two of these teeth mate with like teeth on the unit drum (8), the driving tooth on the switch wheel (14) engages the mated teeth, advancing the tens and unit drums one step. This action moves the unit drum to position zero and the tens drum to the next sequential digit.

h. Hundreds Drum (fig. 78). The hundreds drum (10) is on the bottom of the frame assembly (18) to the left of the tens drum. The hundreds drum is fastened to the frame assembly in the same manner as the unit drum. Description and function of the hundreds drum is the

same as that given for the tens drum, except that the hundreds drum registers 1 digit for every 10 digits registered by the tens drum.

i. Thousands Drum (fig. 78). The thousands drum (11) is at the left of the hundreds drum and is fastened to the frame assembly (18) in the same manner as the unit drum. Its description and function are the same as the tens and hundreds drums, except that the left side has no mating teeth. The thousands drum registers 1 digit for every 10 digits registered by the hundreds drum.

j. Switch Wheel (fig. 78). The three interchangeable switch wheels (14) are above the drums and are fastened to the frame assembly (18) by the switch wheel spindle (6). The right-side switch wheel fits between the unit and tens drums, the middle switch wheel between the tens and hundreds drum, and the left-side wheel between the hundreds and the thousands drums. Each switch wheel has four driver cogs and four holding cogs. The driver cogs engage the paired teeth of the digit drums. The holding cogs lock the drums in place until the paired teeth mate.

k. Retaining Strip (fig. 78). The two interchangeable retaining strips (4) hook over the bottom of the frame assembly at one end and into a mounting hole in the frame assembly (18) on the other end. The retaining strips hold the armature assembly spindle (16), switch wheel spindle (6), and drum spindle (12) between the sides of the frame assembly.

162. Operation

The peg count meter operates in such a manner that an electrical pulse in converted to mechanical motion, and the motion recorded on the numbering mechanism. To achieve these operations, an electromagnet is linked to a mechanical counter. The operations are described below.

a. Operate. When the circuit is completed to the coil assembly, the armature assembly is attracted toward the coil core, and the operations given in (1) through (3) below take place.

(1) The lower arm of the escapement gear engages the gear teeth of the unit drum and rotates the unit drum one-twentieth of a revolution.

(2) The holding gear retains the tens drum in the tens position.

(3) The armature spring is tensioned, preparing it for releasing.

b. Release. When the circuit is interrupted, the armature assembly is released and the operations given in (1) through (3) below take place.

(1) The armature spring is released, restoring the armature assembly to its normal position.

(2) The upper arm of the escapement gear engages the gear teeth of the unit drum and rotates the unit drum one-twentieth of a revolution and retains the unit drum in this position until the next step occurs.

(3) The unit drum turns clockwise, completing the operation and registering one digit.

c. Stepping. When nine digits have been registered, the mating teeth of the units and tens drums engage a driver cog of the right hand switch wheel, advancing the tens drum one digit. Similar action takes place between the tens, hundreds and thousands drum, continuing in this manner until 9,999 counts have registered. The next operation returns the meter to zero.

163. Disassembly (fig. 79)

a. Break the seal (if any) and remove the dust cover (1).

b. Use a split 6-inch screwdriver to remove the slotted retaining nut (2).

c. Unsolder the coil terminals from the terminals of the mounting base and plug (3).

d. Remove the mounting base and plug.

e. Tap the magnet bolt lightly to remove the spacer (4).

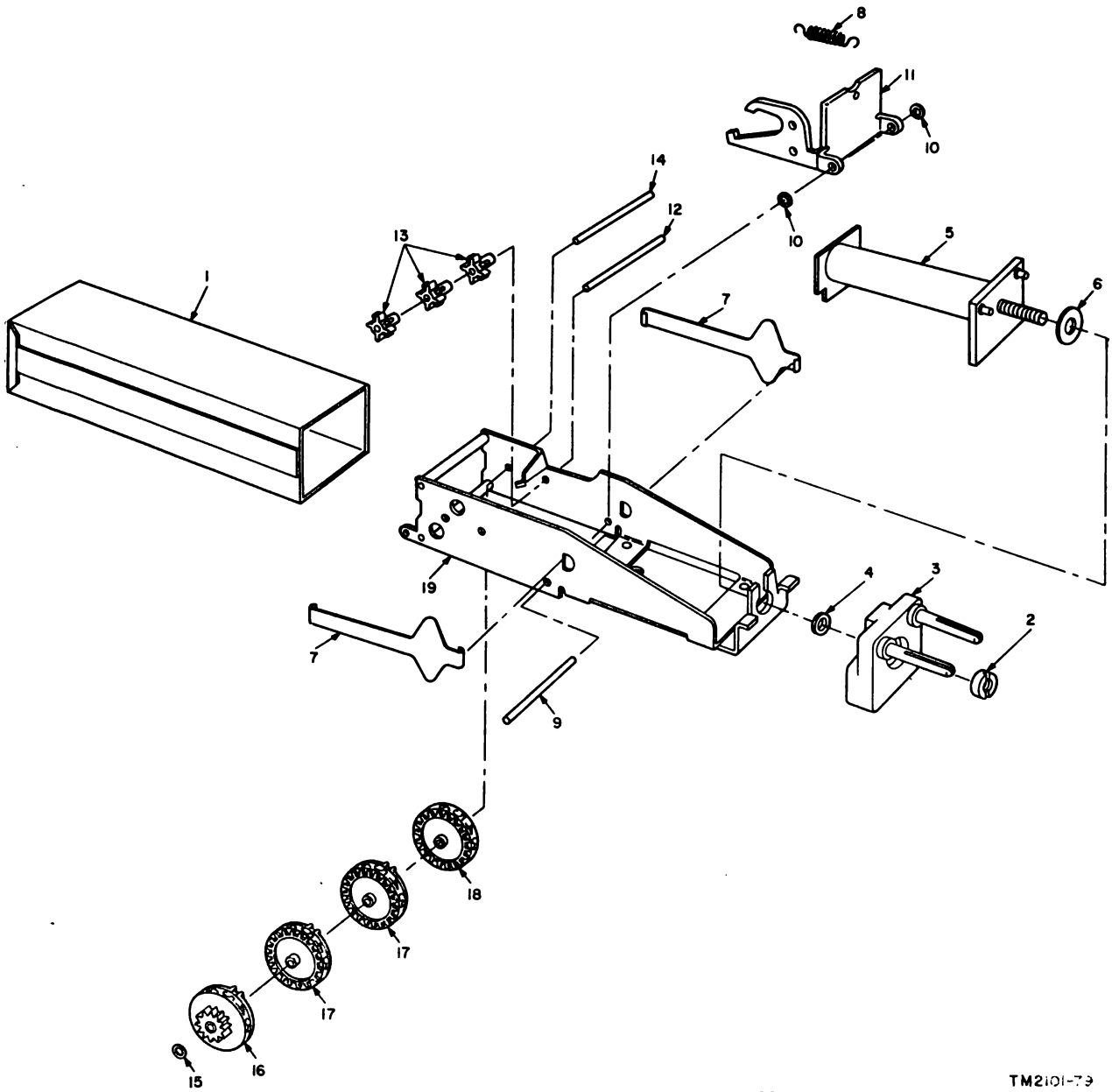
f. Lift out the coil assembly (5).

g. Locate and remove the two shims (2) from the magnet core.

h. Pry back the ends of the retaining strips (7) with a flat-bladed tool and remove it.

i. Unhook the armature spring (8) from the tongue with long-nosed pliers.

j. Press on the end of the armature assembly spindle (9) with a sharp point and remove the two armature assembly spindle washers (10) and the armature assembly and escapement gear (11).



1 Dust cover
2 Retaining nut
3 Mounting base and plug
4 Spacer
5 Coil assembly
6 Shim (2)
7 Retaining strip (2)
8 Armature spring
9 Armature assembly spindle
10 Armature assembly spindle washer (2)
11 Armature assembly and escapement gear
12 Switch wheel spindle
13 Switch wheel (3)
14 Drum spindle
15 Drum spindle washer
16 Unit drum
17 Tens and hundreds drum (2)
18 Thousands drum
19 Frame assembly

Figure 79. Peg count meter, exploded view.

k. Press on the switch wheel spindle (12) and remove it to free the three switch wheels (13).

l. Press on the drum spindle (14) and remove it to free the drum spindle washer (15) and four drums (16, 17, and 18) from the frame assembly (19).

164. Reassembly (fig. 79)

The reassembly instructions provide for the rough adjustment of all assemblies and parts. Specific adjustment instructions are given in paragraph 165 and must be performed before the peg count meter can be put in service.

a. Place the frame assembly (19) down on its right side.

b. Place the unit drum (16) over the mounting hole on the right side of the frame assembly with the gear down (right side).

c. Stack the tens and hundreds drums (17) upon the unit drum with the 20 teeth faced down (right side).

d. Place the drum spindle washer (15) on the left-center raised portion of the thousands drum (18) and insert carefully in the remaining space.

e. Insert the drum spindle (14) through the left side of the frame assembly (19), through the assembled drums and washer (*d* above), and through the right side of the frame assembly.

f. Place the first switch wheel (13) between the thousands and hundreds drums and push the switch wheel spindle (12) down through the frame assembly and switch wheel.

g. Insert the second switch wheel (13) between the hundreds and tens drums and push the switch wheel spindle through the wheel.

h. Insert the third (last) switch wheel between the tens and unit drums and push the switch wheel spindle through the wheel, and then through the right side of the frame assembly. Check the alinement of the driving and holding teeth.

i. Test the drums for proper registry.

j. Slide the armature assembly and escapement gear (11) into place. It should engage the gear teeth on the units drum.

k. Insert one of the two armature assembly spindle washers (10) in each of the spaces between the frame assembly and armature assembly on each side.

l. Insert the armature assembly spindle (9) through the frame assembly washers and armature assembly.

m. Use long-nosed pliers to fasten the armature spring (8) between the tongue on the frame assembly and the mounting hole in the armature assembly.

n. Hook one end of the retaining strips (7) over the bottom of the frame assembly and fasten the other ends into the mounting holes.

o. Slide the two shims over the coil assembly bolt.

p. Place the spacer (4) on the coil assembly bolt and place the coil assembly (5) into the right-angled portion of the frame assembly.

q. Place the mounting base and plug (3) upon the coil assembly bolt. Line up the terminals with the coil assembly terminals.

r. Use the split screwdriver (No. 93) and tighten the retaining nut (2).

s. Solder terminals of the mounting base and plug to the coil assembly terminals.

t. Replace the dust cover (1).

165. Adjustments

a. Checks.

(1) Use a thickness gage to measure the armature air gap. It should measure between .014 and .018 inches.

(2) Operate the armature assembly by hand a selected number of steps. The peg count meter should register the selected number of steps.

(3) Check the alinement of the split male terminals. Both terminals should be straight.

(4) Use the multimeter to check the coil assembly resistance. It should be 1,500 ohms ± 10 percent.

(5) Check for any bent or scored parts.

b. Adjustment Procedures.

(1) Increase or decrease the armature spring tension, as required, to achieve the proper air gap spacing by bending the tongue in or out with the long-nosed pliers.

(2) Use the long-nosed pliers and carefully straighten any bent terminal. Be careful not to disturb the spacing of the slot.

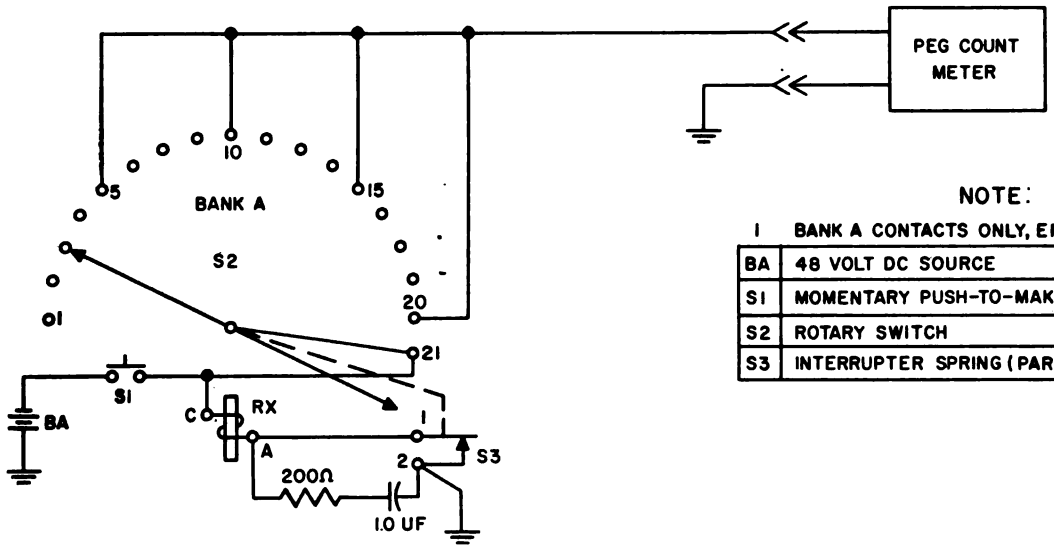


Figure 89. Test setup, peg count meter.

(3) Adjust the switch wheels for proper alinement with their associated drums. The holding teeth and driving teeth should be alined on the spindle.

166. Final Testing

a. Operational (In Service) Final Testing. The peg count meter registers the succeeding digit each time a circuit plate is seized or a push switch is operated at the switchboard. To perform an operational test on the peg count meter, connect the meter in a working circuit and observe its operation.

b. Bench Final Testing (fig. 80).

(1) Follow the procedure in (*a*) through (*h*) below for the test setup.

(*a*) Connect negative battery (BA) to one side of the momentary push-to-make switch (S1).

(*b*) Connect the other side of BA to ground.

(*c*) Connect the other side of S1 to terminal C of RX and to terminal 21 (brush spring) of the rotary switch (S2).

(*d*) Connect terminal A of RX to terminal 1 of the interrupter springs (S3).

(*e*) Connect a 200 ohm resistor in series with a 1 microfarad capacitor across terminal 1 and 2 of S3.

(*f*) Connect terminal 2 of S3 to ground.

(*g*) Connect terminals 5, 10, 15, and 20 to one side of the peg count meter.

(*h*) Connect the other side of the peg count meter to ground.

(2) Record the reading on the peg count meter.

(3) Operate switch S1 for 1 minute.

(4) When switch S1 is released, the peg count meter should register 600 ± 120 counts.

Section III. JACKS, PLUGS, AND CORDS

167. Jacks

The jack strip illustrated in figure 81 is typical of those used in the XY dial central office equipment. The procedures used to clean and lubricate jacks are contained in paragraph 195. For additional information for the adjustment of all types of jacks, refer to TM 11–4302.

168. Plugs and Cords (fig. 82).

The plug and cord illustrated in figure 82 are typical of those used in XY dial central office equipment. The procedures used to clean and lubricate the plugs and cords are contained in paragraph 195 of this manual.

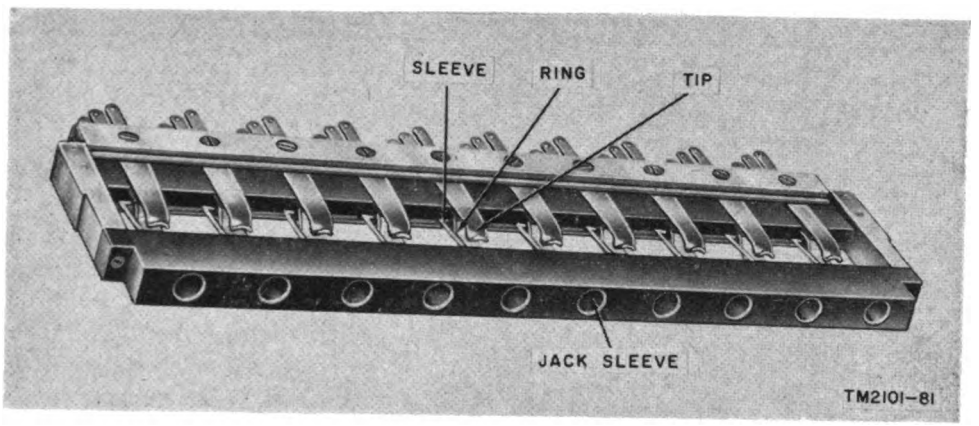


Figure 81. Jack strip.

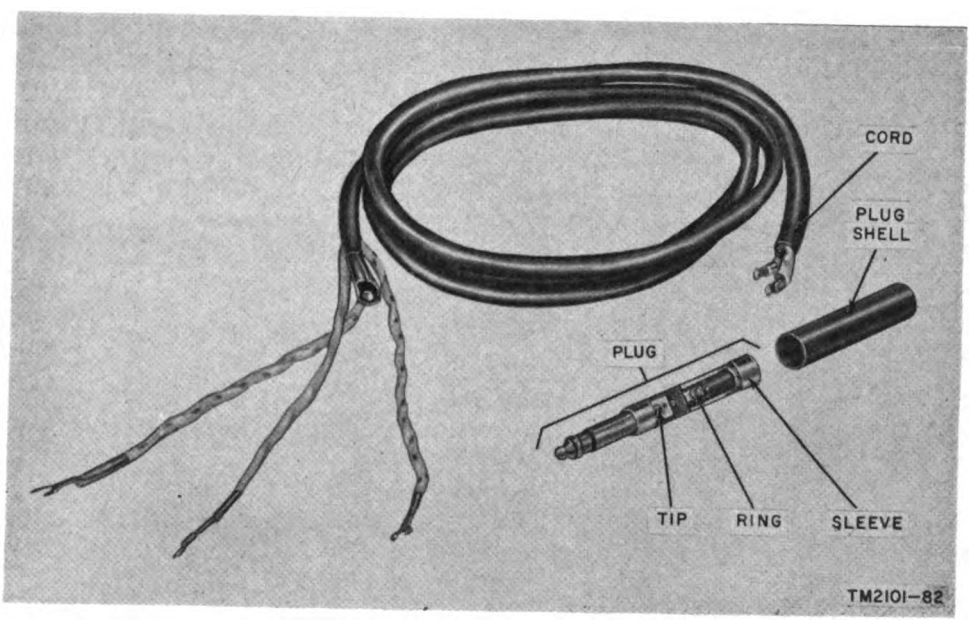


Figure 82. Plug and cord, typical.

CHAPTER 6
RELAYS

Section I. GENERAL

169. Introduction (fig. 83)

The XY dial central office equipment uses two types of relays, designated as the A-type and C-type relays. The A-type and C-type relays are very similar in construction and appearance. The major differences between the two relays are as follows.

a. The A-type relay has a single armature and a single coil. The C-type relay has two separate armatures and coils.

b. The A-type relay armature is held to the frame by a spring retainer. The C-type relay armatures are held to the frame by screws.

c. The power distribution circuits contain relays other than A and C types. For details concerning the relays in the power circuits, refer to the publication covering XY dial central office equipment (power ringing and supervisory equipment)

170. Classifications of A- and C-Type Relays

a. Fast Acting. Fast acting relays may have a range of operate time of .008 to .02 second and a range of release time of .008 to .02 second.

b. Slow Acting. The range of operate and release times of these relays depend on several factors, such as the pileup, number of coil winding turns, and current flow. Retarded operation and release is also accomplished by a copper sleeve over the coil core. This delays buildup and decay of magnetic flux in the core.

c. Slow Operate. Slow operating relays may have a range of operate time of .020 to .130 second and a range of release time of .110 to .210 second. This type of relay has a copper slug at the armature end which causes a time delay between circuit closure and relay operation.

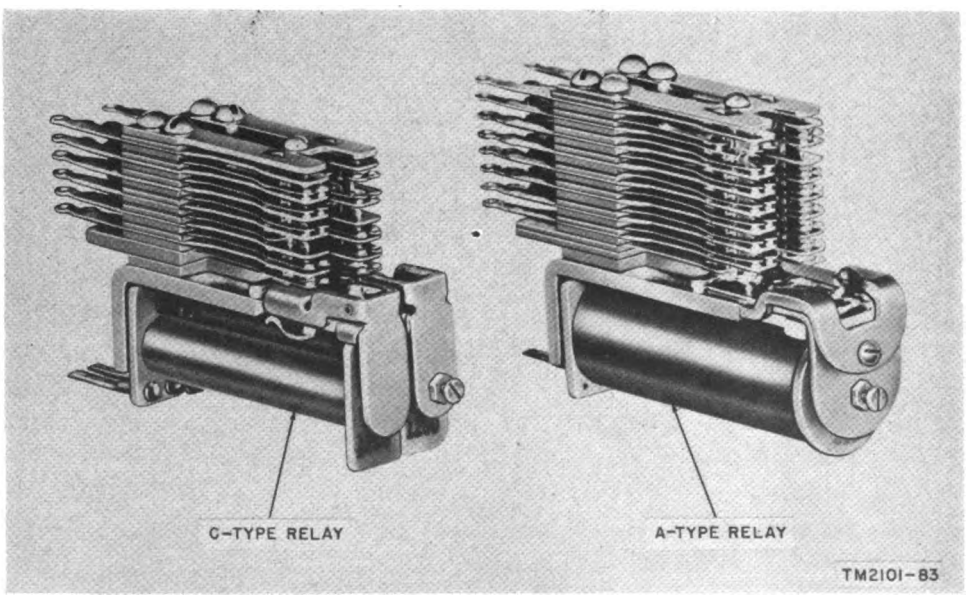
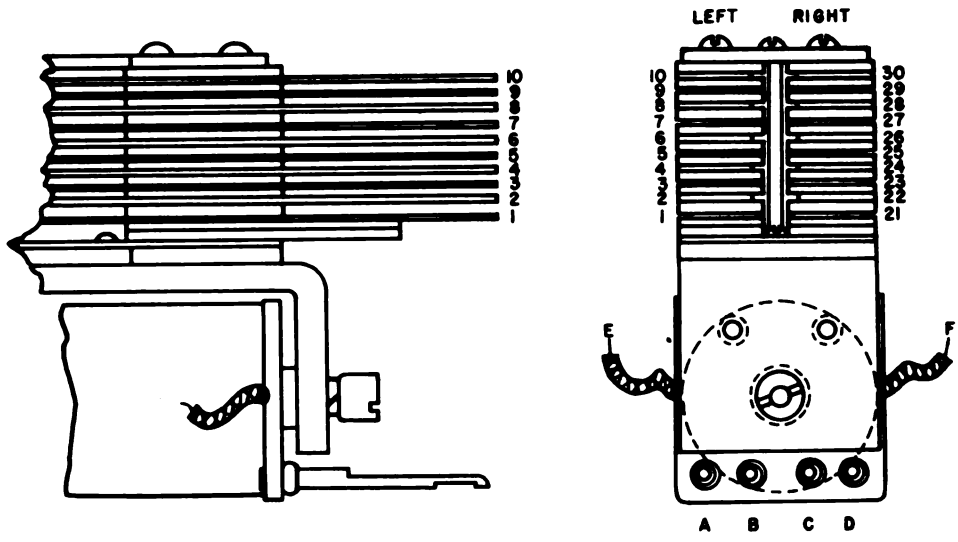
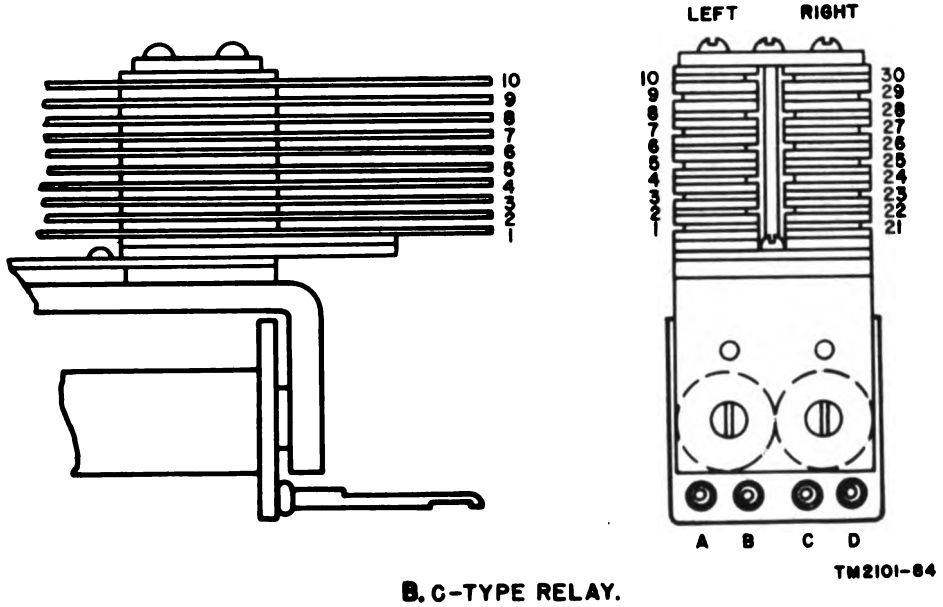


Figure 83. A- and C-type relays.



A. A-TYPE RELAY



B. C-TYPE RELAY.

Figure 84. Numbering of springs and coil winding terminations.

d. Slow Release. Slow-releasing relays may have a range of operate time of .005 to .095 second and a range of release time of .045 to .135 second. This type of relay is similar to the slow-operating relay, except that the copper slug is located at the heel end of the coil core to delay flux decay in the magnetic circuit. This allows the relay to remain in its operated position for a short time after the circuit has been opened.

171. Spring Numbering for A- and C-Type Relays

The method of numbering springs of relay spring pileups for both A- and C-type relays is illustrated in A and B, figure 84. Position the relays with spring pileups on top of the frame and spring connection terminals (rear portion of the relay) facing toward the viewer. For dual spring pileups, two series of numbers are

used, 1 to 20 for the left spring pileup and 21 to 40 for the right spring pileup. For a single spring pileup, only the 1 to 20 series of numbers are used. Spring numbering begins at the bottom of the pileup and proceeds upward consecutively. For example, the bottom spring of the left pileup is numbered 1, whereas the bottom spring of the right pileup is number 21. This is so, even though the spring numbering for the left pileup does not reach number 20. The maximum number of springs in a single pileup for relays used in this equipment does not exceed 20.

172. Coil Winding Terminal Designations

Coil winding designations differ for the A- and C-type relays. Refer to figure 84 for an illustration of the terminal locations and designations. The relay is viewed from the rear, facing the terminals with the spring pileup at the top.

a. A-Type Relay. The coil winding terminals are designated from left to right A, B, C, and D. In a single-wound coil, the winding generally begins at terminal A and terminates at terminal C. In some coils, such as the coils of slow release relays, the winding begins at terminal A and terminates at terminal D. In a double-wound coil, the second winding begins at the B terminal and terminates at the D terminal. Should there be a third winding, the ends of the tertiary windings are brought out to flexible leads and connected as required. They are designated E and F; the winding begins at E and terminates on F.

b. C-Type Relay. The C-type relay coil winding terminal designations A, B, C, and D, are the same as those for the A-type relay. Each of the two coils of the C-type relay has a single winding. One winding of the C-type relay begins at terminal A and terminates at terminal B, while the second winding begins at terminal C and terminates at terminal D.

Section II. DESCRIPTION AND OPERATION OF RELAYS

173. Description of A-Type Relay

The A-type relay consists of four major assemblies: frame, coil, armature assembly, and dual spring combination assembly. Some A-type relays, however, may be equipped with only a single spring combination assembly (spring pileup). All of these components are mounted on a single relay frame.

174. Description and Function of Component Parts, A-Type Relay (fig. 85)

a. Frame. The frame (16) is made of iron with a zinc or nickel plated finish. It functions as a mounting base for all major components of the relay. Two No. 8–32 tapped holes are provided on the rear of the frame for mounting the relay on a circuit plate. The frame also acts as a magnetic return path for the core. A spring retainer is welded to the top of the frame at the armature assembly end. It holds the armature assembly (commonly referred to as the armature) in place on the frame by means of its spring clip action, but allows the armature assembly to move freely on its pivot at the front of the relay frame.

b. Coil. The coil core (2) is made of iron, plated with nickel, and insulated from the coil (1) by a sleeve of triple layer, laminated, cellulose acetate. Coil windings, made of enamel insulated wire, may be single or double wound around the insulated core. Noninductive windings are sometimes wound on the core with inductive windings. The assembled coil is fastened to the rear of the relay frame by means of a threaded stud and a nut (17). When energized, the coil becomes an electromagnet, attracting the armature to the coil core.

c. Armature Assembly. The armature assembly consists of four parts: armature residual plate (3), residual screw (4), and nut armature support plate (6), and armature support plate mounting screw (5). The residual and support plates are made of iron and are usually zinc plated but may be nickel plated to improve the magnetic properties. The armature is held in place by means of a metal spring retainer (part of the frame). When a relay is operated, the armature pivots on its knife-edge bearing in such a manner to produce an upward movement beneath the springs. This movement actuates the spring pusher (11) which (inturn) actuates the movable light springs (9) so that they make and/or break contact with the stationary heavy springs (10).

(1) *Armature residual plate.* The armature residual plate is equipped with either a welded nonmagnetic residual disk (projection) or an adjustable brass residual screw.. The projection of the residual determines the minimum operated air gap. This adjustment prevents the armature of a deenergized relay from sticking to the coil core because of residual magnetism.

(2) *Armature support plate.* The armature support plate is attached to the armature residual plate by means of an armature support plate mounting screw. The armature movement or travel may be varied by rotating the screw.

d. Spring Combination Assembly. This assembly generally consists of two separate spring combination assemblies (pileups) joined together into a single assembly with a clamping plate (14) at the top and a mounting plate (15) at the bottom. The entire assembly is mounted to the top of the relay frame with a mounting plate screw (13) and a clamping plate screw (12). Some relays are equipped with a single spring combination assembly. A spring combination assembly, commonly known as a spring pileup, consists of one or more spring combinations, stops, and pushers. Phenolic spring pushers (11), inserted through clearance slots in each spring of the spring pileup, act to move the movable light springs (9) of each pileup upward when the pusher itself is actuated in an upward direction by the armature of an energized relay. In this manner, spring contacts make or break to close or open the switching circuits controlled by the relay. When the relay is deenergized, the armature releases and the spring pusher returns to rest on the armature. For those A-type relay spring pileups which include X- or M-type spring combinations, the pusher drops to rest on a metal pusher stop (19) restoring springs to their normal positions. In slow release type relays, when the armature returns to rest, an armature lever arm (20) acts as a stop for the pusher. In addition, a phenolic, card-type spring stop (8) provides tension for the stationary heavy springs (10) and maintains proper positioning between springs.

(1) *Spring combination.* A spring combination may be composed of any combination of light, heavy, and force springs (7), separated by insulators. The various types of standard spring combinations which may be used in relay construction are shown in figure 86. Special types such as M and X combinations are also shown. The M-type spring combination requires a smaller movement of the armature to operate its contacts than the normal spring combination. The X-type spring combination operates before other combinations in the same pileup. Any spring combination mounted on a limited travel relay is referred to as an L combination. A limited travel relay has a large residual screw and special adjustment requirements. This feature is especially important in pulsing relays.

(*a*) *Light springs.* The light springs are of the flat, cantilever type. They are made of nickel-silver and bifurcated (forked) at the front end to form two tines (prongs) with a narrow clearance slot between them. The clearance slot permits insertion of the phenolic card-type stops. Just beyond the bifurcated end of the spring, another clearance slot (separated from the front clearance slot by a narrow bridge) permits insertion of the pushers. The front ends of the forked springs may be equipped with domelike or crossbar type twin contacts made of silver or palladium. The rear end terminals of the springs may be either tapertab or solder type for wiring connections.

(*b*) *Heavy springs.* The heavy springs are of the flat, cantilever type and are made of nickel-silver. They are not forked at the front end as are the light springs. The front ends have twin-type contacts to match those on the light springs which make or break with the heavy springs. The clearance slots permit insertion and free movement of

pushers and stops. The rear end terminals of the springs may be either taper-tab or solder type for wire connections.

(c) *Force springs.* The force springs are of the flat, cantilever type and are made of nickel-silver. They are not forked at the front end as are the light springs. They are equipped with rectangular clearance slots at the front end to permit insertion and free movement of the pushers. These springs are much shorter than the other springs in the pileup. Since they are not equipped with contacts at the front or rear end, they are never part of the electrical circuit. They are used to maintain tension against the moveable springs of the spring pileup.

(2) *Stops.* Two types of stops are used on A-type relays (fig. 85); the light spring pusher stops (19) and the heavy spring stops (8).

(a) *Light spring pusher stop.* The pusher stop is mounted on top of a relay frame which is equipped with spring pileups containing X- or M-type spring combinations. Its raised end acts as a rest for the light spring pusher when the relay armature is at normal.

(b) *Heavy spring stop.* The heavy spring pusher stop is a card-type strip of phenolic fiber material provided with small projecting hooks. It is inserted through the slotted openings at the front ends of each spring of the pileup to maintain the position of the heavy springs in the pileup. The uppermost portion of the stop rests against the underside of the clamping plate (14).

(3) *Pushers.* Two types of pushers are used in the A-type relay: the spring pusher (11) and the cylindrical pusher (18).

(a) *Spring pusher.* The spring pusher is a card-type strip of phenolic fiber material provided with small projecting hooks. It is inserted through rectangularly slotted clearance openings (just beyond the front end clearance slots of each spring) in a pileup. It is positioned so that its hooks engage and move the light springs when the pusher is actuated by the armature. The pusher action insures simultaneous and accurate movement of all light springs engaged by its hooks.

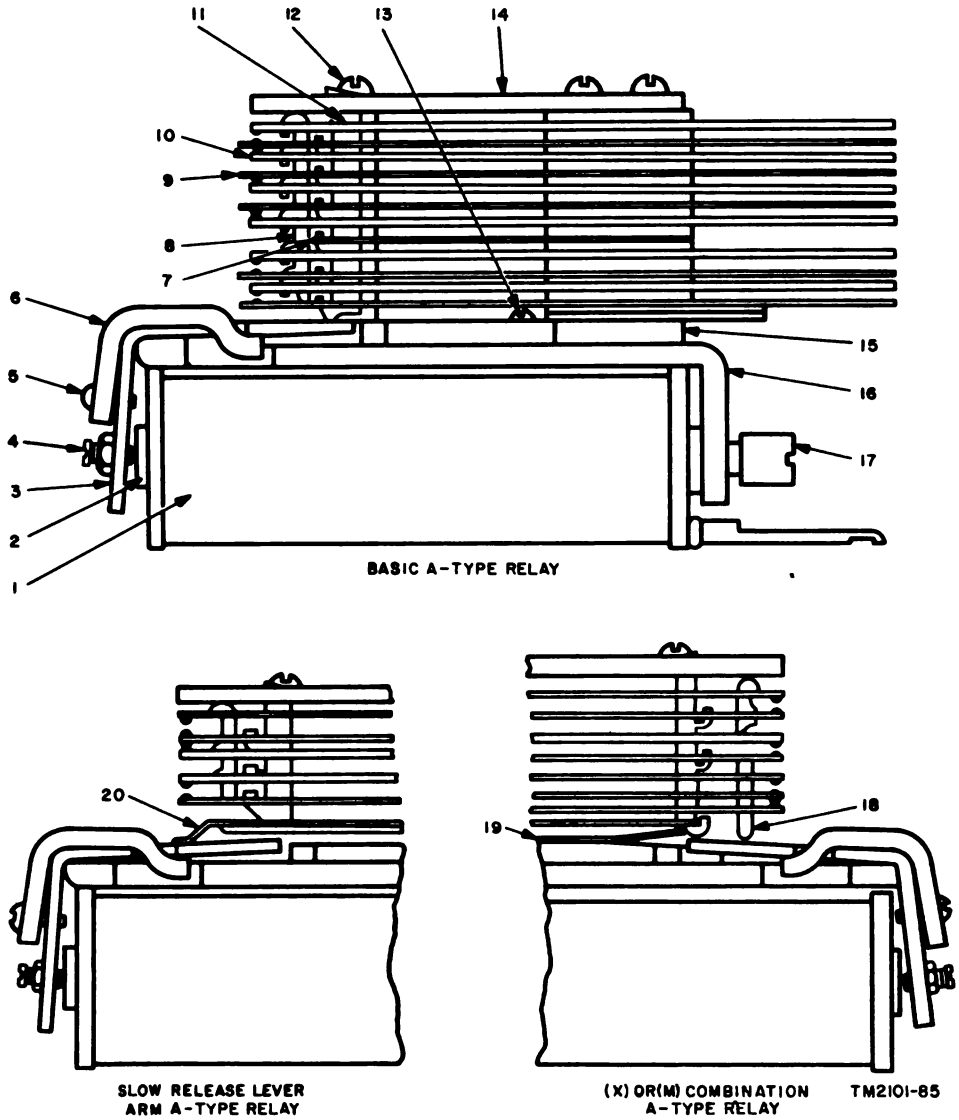
(b) *Cylindrical pusher.* The cylindrical pusher is a small post made of insulating material. It is fastened to one of the moveable springs and extends through the slot at the contact (front) end of the light springs of X- and M-type spring combinations; the pusher is actuated by the armature. In turn, the pusher actuates the light springs to make and/or break contact with the associated heavy springs, prior to the make and break action of other spring combinations in the pileup.

175. Operation of A-Type Relay

A magnetic field is produced when current is applied to the windings of a relay coil. The magnetic field produced attracts the armature toward the coil core. As the armature moves on its pivot, it causes an upward movement of the pusher. The pusher, in turn, moves the light springs to make or break contact with the associated heavy springs. This action opens or closes circuits controlled by the relay. When current through the relay winding ceases, the magnetic field collapses, and the armature and springs return to their normal (unoperated) position.

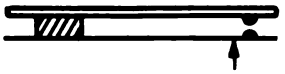
176. Description of C-Type Relay

Figure 83 illustrates a typical C-type relay. It is equipped with dual spring pileups which may be composed of one or more of the standard spring combinations illustrated in figure 86. Each relay section operates its own spring pileup independently of the other. The total number of springs in a single spring pileup section may not exceed 20.

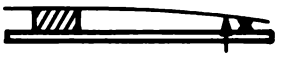


1 Coil
2 Coil core
3 Armature residual plate
4 Residual screw and nut
5 Armature support plate mounting screw
6 Armature support plate
7 Force spring
8 Heavy stop
9 Light spring
10 Heavy spring
11 Pusher
12 Clamping plate screws (4)
13 Mounting plate screw
14 Clamping plate
15 Mounting plate
16 Frame
17 Coil mounting stud nut and washer
18 Cylindrical pusher
19 Pusher stop
20 Lever arm

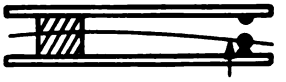
Figure 85. Location of component parts, A-type relay.



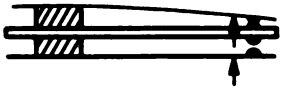
MAKE (A) COMBINATION



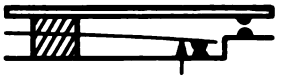
BREAK (B) COMBINATION



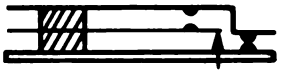
BREAK-MAKE (C) COMBINATION



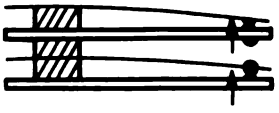
BREAK-MAKE (IC) COMBINATION



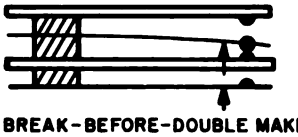
MAKE-BEFORE-BREAK (D) COMBINATION



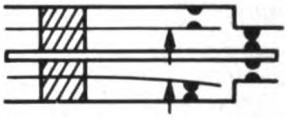
MAKE-BEFORE-BREAK (K) COMBINATION



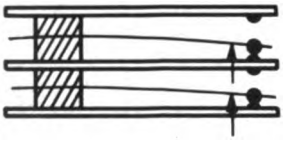
DOUBLE BREAK-BEFORE MAKE (G) COMBINATION (B+C)



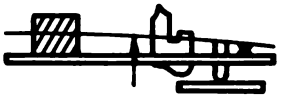
BREAK-BEFORE-DOUBLE MAKE (J) COMBINATION (A+C)



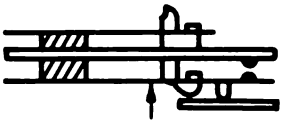
DOUBLE MAKE-BEFORE-DOUBLE BREAK (F) COMBINATION (D+K)



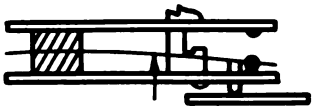
DOUBLE BREAK-BEFORE DOUBLE MAKE (Z) COMBINATION (C+C)



PRELIMINARY BREAK (XB) COMBINATION



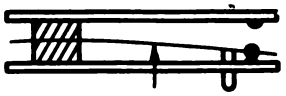
PRELIMINARY MAKE (XA) COMBINATION



PRELIMINARY BREAK-MAKE (XC) COMBINATION

LIGHT LOAD MAKE (MA) COMBINATION

LIGHT LOAD BREAK (MB) COMBINATION



LIGHT LOAD BREAK-MAKE (MC) COMBINATION

NOTE:
ALL COMBINATIONS ARE SHOWN IN NON-OPERATED POSITION.

TM2101-86

Figure 86. Spring combinations.

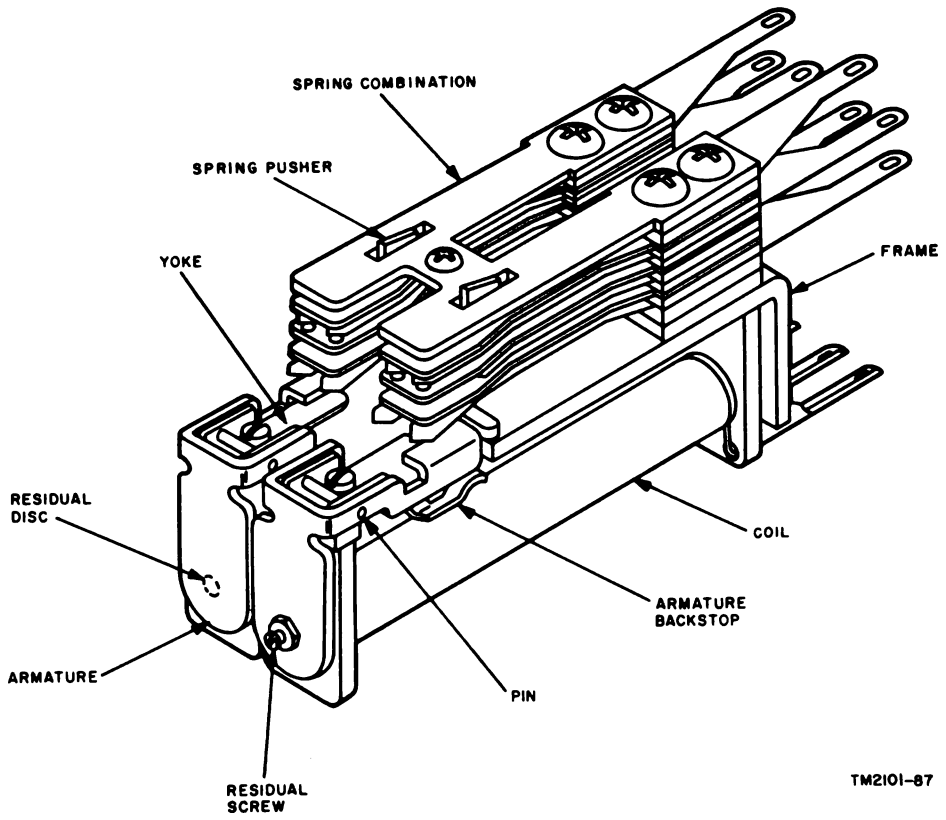


Figure 87. Location of component parts, C-type relay.

177. Operation and Function of Component Parts, C-Type Relay (fig. 87)

a. General. The component parts of the C-type relay are basically similar in construction, function, and operation to those of the A-type relay. The only exception is the C-type relay armature (*b* below).

b. Armature Assembly. The C-type relay uses two separate armature assemblies. In operation, each armature actuates its own independent spring pileup. Either armature may be equipped with a nonadjustable residual disk welded to the inner face of the armature residual plate, or with an adjustable residual screw. Each armature of the C-type relay is pivoted on a nonmagnetic pin mounted in a brass yoke.

Section III. RELAY ADJUSTMENT AND REPAIR

178. General

These relays do not normally require frequent adjustment or repair. Some adjustments and repairs become necessary, however, when there is contact wear or loss of spring tension.

a. Procedure.

(1) *Inspection.* The relays should be inspected in accordance with the procedures listed in paragraphs 189 through 191.

(2) *Electrical Testing.* The relays should be tested with the Stromberg-Carlson type 6B Current Flow Test Set and the relay adjustment (RA) tables before proceeding with the mechanical adjustments. The use of these tables is described in paragraphs 189 through 191.

(3) *Mechanical Adjustments.* The necessary mechanical adjustments should be made in accordance with the proce-

dures listed in paragraphs 181 through 184. When these adjustments have been completed, the relay should be checked electrically again.

b. Tools and Materials Required. The special tools and materials required for maintenance of the A- and C- type relays are listed in the table below.

Manufacturer's tool No.	Tool	Function
24	Screwdriver and socket wrench	Adjustment of residual screws and locknuts.
65	Spring adjuster	Forming the force springs of A- and C-type relay.
100	Spring adjuster	Adjustment of front end of heavy break springs on A-type relays.
268	Spring adjuster	Adjustment of front end of heavy break springs on C-type relays.
78	Armature and backstop adjuster	Adjustment of armatures and backstops on C-type relays.
72	Clamping plate and armature backstop adjuster.	Adjustment of backtop on A-type relays and the spring clamping plates on A- and C- type relays.
66	Spring adjuster	Forming the contact ends of springs on A- and C- type relays.
74	Relay spring tool	Removal and replacement of pushers and stops of A- and C-type relays having from 6 to 9 hooks.
73	Relay spring tool	Removal and replacement of pushers and stops of A- and C-type relays having from 1 to 6 hooks.
77	Thickness gage set	Checking residual and contact spacing of A- and C-type relays.
Sig C stock No. 6R40868C 6R408704, or 6Q45235	Gram gage	Determining contact pressure of A- and C-type relay springs.
	Long flat-nosed pliers	Straightening relay spring terminals.

c. Materials. The maintenance materials required for A- and C-type relays are listed below.

Glyptol cement, manufacturer's stock No. 207350.
Lint-free cloth.
Cleaning Compound, Federal stock No. 7930–395–9542.
Heavy bond paper.
Toothpicks.

179. Relay Adjustment Data

The data in the relay adjustment tables provide information regarding all relays in any given circuit. These tables indicate specified test and adjustment values and tolerances for relays. The relay adjustment tables must be used in conjunction with adjustment and repair procedures. Relays need not be removed from their circuit plates for these tests and adjustments but the circuit plates must be busied out prior to testing or adjusting them. A detailed explanation of these adjustment tables and their uses is provided in paragraphs 189 through 191.

180. General Requirements For Adjusting A-Type Relays

Relay adjustments are interdependent. The spring tension, for example, affects both the operating and release current. For these reasons, adjustment of a relay is primarily a series of approximations, each adjustment affecting all others to a certain degree.

a. Removal of Circuit Plate Dust Covers. All relays are mounted on circuit plates. Each plate is equipped with a snap-type dust cover which can be easily removed.

Note. Be sure to busy out the circuit plate containing the relays to be tested or adjusted.

b. Inspection.

(1) Visually inspect the relays for loose mounting screws and tighten them if necessary.

(2) Check the armature for dirt between its pivot and spring retainer.

(3) Actuate the armature manually and observe whether the spring pushers

move freely in their slots. The light springs should all move in unison when the spring pusher is actuated. In spring pileups containing X spring combinations (fig. 86), note that these spring combinations move prior to the spring combinations actuated by the spring pusher. When the armature is released, the spring pushers should rest on their stops.

(4) Observe the mating contact alinement. The maximum allowable deviation from complete alinement is approximately one-third of the contact diameter, as judged visually.

(5) If the relay has a lever arm, raise it slightly to make sure that it does not bind on its pivot. Both ends of the lever arm should rest on the armature. The lever arm should not raise off the pivot when the armature is operated.

(6) Check the stud and nut and tighten them if necessary.

(7) Check the residual air gap (the space between the armature and the coil core, with the relay operated). For the air gap requirements refer to the designated relay on the appropriate relay adjustment table.

Note. Under no conditions should a relay be adjusted so that the operated air gap is not perceptible to the eye. If this condition occurs, the relay may be held operated by residual magnetism after current is cut off.

(8) Check the spring gaging with a standard thickness gage placed between the manually operated armature and core, with the end of the gage just covering the residual projection (fig. 88). Observe that the contacts make or break. Heavy springs are preformed to exert pressure against the spring stop. Light springs are preformed to exert pressure against back contacts or against the spring pusher. If springs are badly bent, remove the pushers and stops before attempting to restore the springs to their preformed shape. When springs are only slightly deformed, the pusher stops and spring pushers should be left in place while spring adjustments are made.

***Caution:* When it becomes necessary to bend a relay spring, in order to restore a relay to satisfactory operating efficiency, be careful not to break the pushers or stops. Push and hold the unaffected springs away from the spring to be reformed. Bend the spring, at the front end only, until it is restored to such tension as to enable the affected spring combination to meet contact gaging requirements.**

(9) Check the contact pressure for a reduction of pressure due to contact wear and the inclination of the metal springs to assume their original shape after many operations. Adequate pressure breaks down normal deposits of dust or dirt and provides a stable electrical contact with a low and constant resistance.

(*a*) Light contact pressure permits dust and dirt to hold the contacts open electrically when they appear to be mechanically closed.

(*b*) Contact resistance tends to increase and becomes variable because of vibration of adjacent apparatus as contact pressure becomes lower.

(*c*) Variation in contact resistance varies the amount of current flow, causing failures in signaling circuits and noise in transmission circuits to occur.

c. Electrical Testing. Check the electrical operation of the relay; use the electrical operating requirements given on the relay adjustment tables for each relay. Use the Stromberg-Carlson type 6B Current Flow Test Set to check the operate (O), nonoperate (NO), hold (H), and release (R) current values. If the relay meets these requirements, the relay should function properly in its circuit. Relays which do not operate properly at current test value should be readjusted to meet the readjust values specified. Additional adjustments are sometimes specified in the Remarks column and should be noted before testing or readjusting the relay.

181. Mechanical Adjustments of A-Type Relays

a. General. Be careful in the use of the tools necessary for mechanical adjustment of the re-

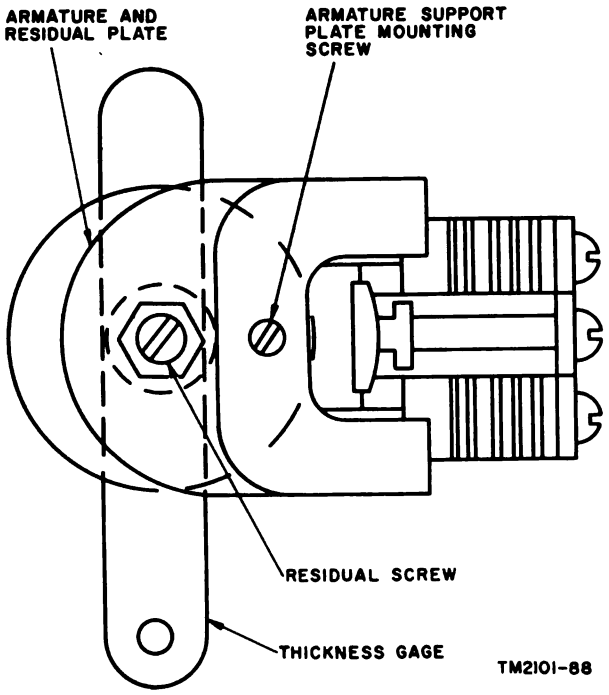


Figure 88. Checking contact gaging.

lays. Keep all adjustments to the tolerances specified in the instructions on relay adjustment tables.

b. Armature Residual (fig. 89). The A-type relay may be equipped with either a nonadjustable welded disk-type residual or an adjustable residual screw. The residual air gap for relays with or without residual screws is given in the applicable relay adjustment table. For relays with nonadjustable residuals, it is only necessary that a .002 gage be loose when inserted between the armature and core of the relay. The adjustable residual screw controls the amount of space between the armature and the coil core with the relay electrically operated. To adjust the residual screw projection for proper air gap, follow the procedure in (1) through (6) below.

(1) Use a screwdriver and socket wrench to loosen the locking nut slightly.

(2) Operate the armature by hand.

(3) Insert the specified thickness gage between the armature and the core while holding the gage parallel to the pivot edge just clearing the residual screws.

(4) Check the fit of the thickness gage. Adjust the screw until the gage fits snugly between the armature and the core.

(*a*) For residual projections specified as .010 inch or smaller, a gage .001 inch smaller than the specified projection must fit loosely and a gage .001 inch larger than the specified projection must fit tightly. For example, for a specified residual projection of .004 inch, a .003 inch gage should fit loosely between the armature and the coil core and a .005-inch gage should fit tightly.

(*b*) For residual projections specified as .011 inch or larger, a gage .002 inch smaller than the specified projection must fit loosely when inserted between the armature and the core and a gage .002 inch larger than the specified projection must fit tightly. For example, for a residual projection specified as .012 inch, a .01-inch gage should fit loosely between the armature and the core, and a .014-inch gage should fit tightly.

(5) Recheck the residual projection after tightening the locking nut.

(6) For relays which have release time or hold current requirements, the residual screw setting may be varied from the setting specified on the relay adjustment table in order to obtain desired operating characteristics. At all times, however, there must be perceptible residual gap and proper contact pressure.

c. Make Contact Gaging. The armature position at which the contacts make and break may be checked by inserting the specified thickness gage between the armature and the coil core (fig. 88). The end of the gage must just cover the residual projection, and the relay must be electrically operated while making the check. If readjustment is required, turn the armature support plate adjusting screw in the clockwise direction with a small screwdriver. The armature support plate mounting screw should be sealed with glyptol cement. This adjustment will compensate for normal contact wear. If, during adjustment, the screw is turned in too far, remove the armature and armature support and reform the armature by bending it inwards. To seat the armature support plate adjusting

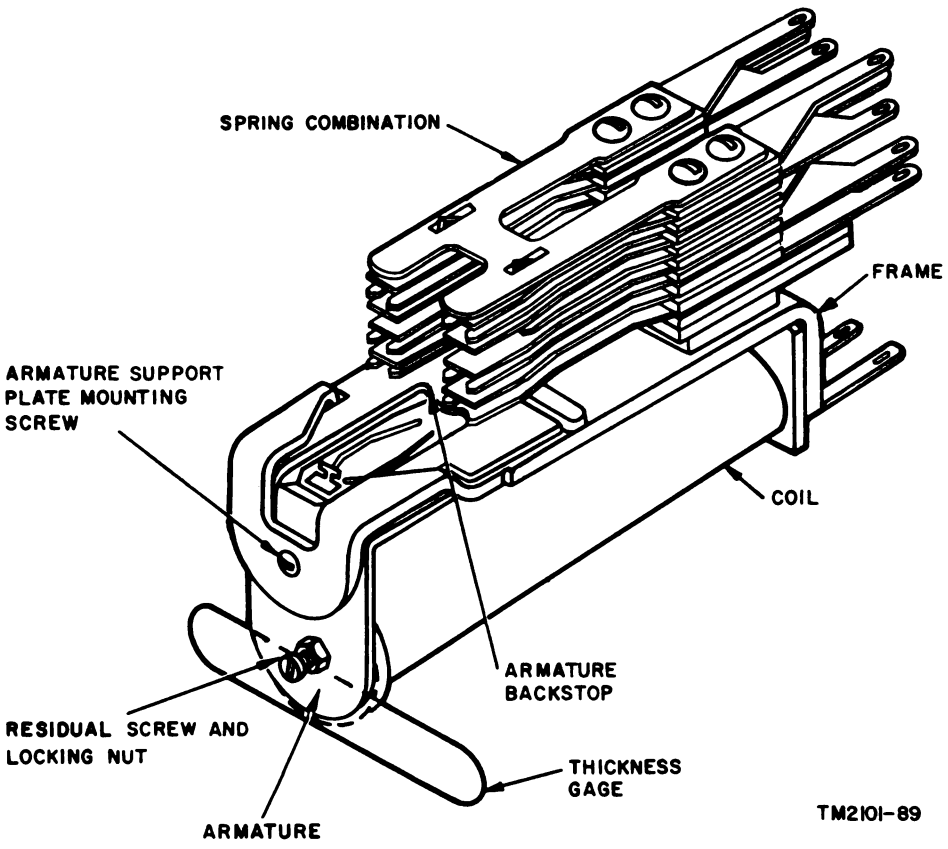


Figure 89. Checking armature residual.

screw, it may also be necessary to reform the armature by bending it outward. If a relay has two spring pileups and is badly out of adjustment because of damage, it may be necessary to bend the front end of the spring combination clamping plate to even up both pileups. This will cause the make contacts of both pileups to make at the same time.

d. Break Contact Gaging. When the make contacts are properly adjusted, the break contacts will probably be in correct adjustment. However, if readjustment is necessary, the front end of the heavy break springs may be adjusted with the spring adjusting tool. During this adjustment, be very careful not to damage the pusher or stop. If, after the heavy spring adjustments have been made, the relay fails to meet its specified electrical requirements, adjust the tension of the break springs by using the proper spring adjuster tool to readjust the spring. The tool selected will depend on the thickness of the spring to be adjusted.

e. Armature Backstop Adjustment (fig. 90). Inserting the projection of the adjusting tool into the hole in the armature backstop and twisting this section of the armature to meet the requirements.

f. Pressure Gaging. Adjust the tension of break springs with the proper spring adjusting tool (fig. 91). After springs have been adjusted, either by preforming or by adjusting the armature support screw, check the pressure with a pressure gage (A and B, fig. 92).

182. Contact Gaging Specifications and Armature Backstop Settings for A-Type Relays

a. A, through D, LC, and K Combinations without Lever Arm.

(1) *Make contacts (six hooks or less on pushers).*

(*a*) *Tests.* All make contacts of combinations six steps or smaller, except those of make-before-break and

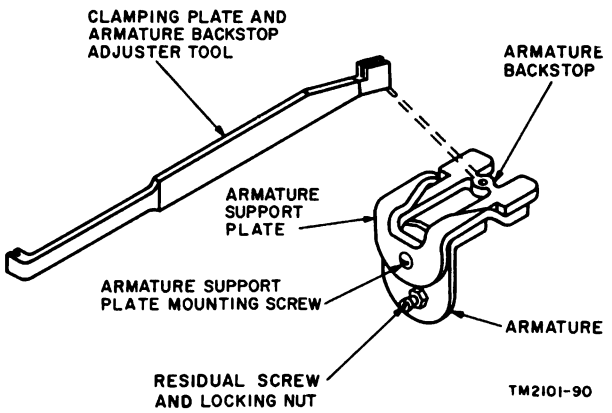


Figure 90. Adjusting armature backstop.

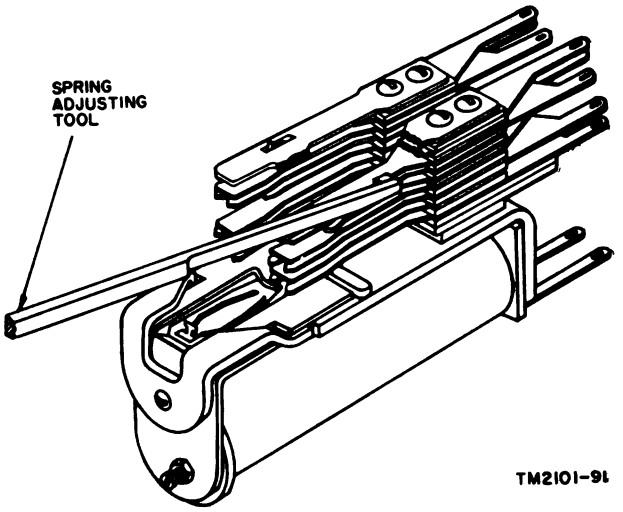
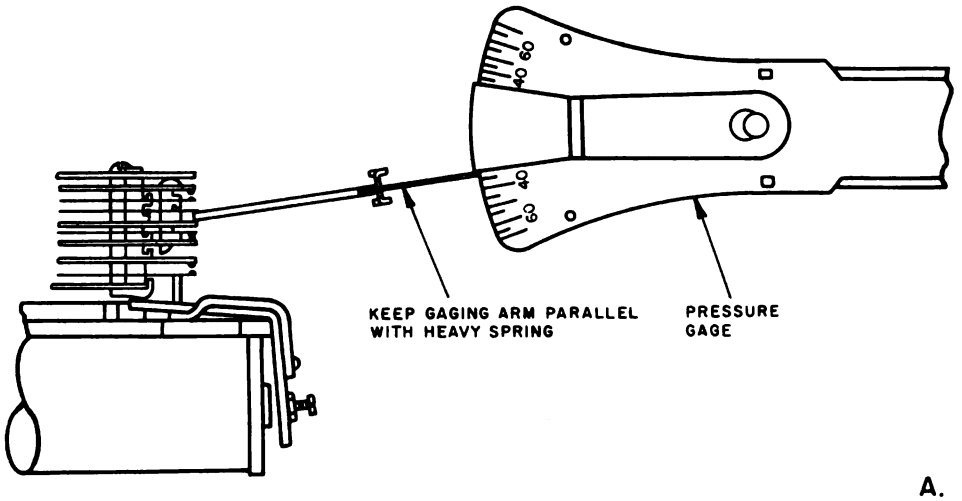


Figure 91. Adjusting spring tension.



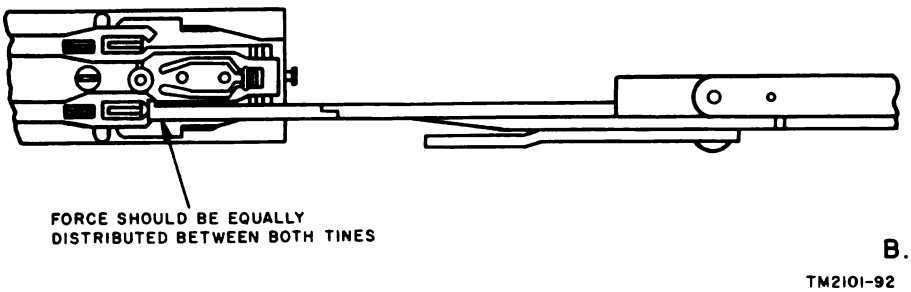


Figure 92. Checking spring pressure.

(X) combination, must be inspected to make on a .003-inch gage, but must not make on a .007-inch gage.

(*b*) *Readjust.* If the relay does not meet the inspection requirements, it must be readjusted to make on a .0045-inch gage, but must not make on a .0055-inch gage.

(2) *Make contacts (more than six hooks on pushers).*

(*a*) *Test.* Combinations greater than six steps must be inspected to make on a .004-inch gage, but not on a .008-inch gage.

(*b*) *Readjust.* If the relay does not meet the inspection requirements, it must be readjusted to make on a .0055-inch gage, but not on a .0065-inch gage. Contact separation must be a minimum of .008 inch.

(3) *Break contacts (six hooks or less on pushers).*

(*a*) *Test.* All break contacts six steps or smaller except those of make-before-break and (X) combinations, must be inspected to break on a .007-inch gage and must have a 25 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If the relay does not meet the inspection requirements, it must be readjusted to break on a .0085-inch gage, but not on a .0095-inch gage. In readjustment there must also be 25 grams minimum and 40 grams maximum contacts pressure for each pair of twin contacts.

(4) *Break contacts (more than six hooks on pushers).*

(*a*) *Test.* Combinations greater than six steps must be inspected to break on a .008-inch gage and must have 25 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If the relay does not meet the inspection requirements, it must be readjusted to break on a .0095-inch gage, but not on a .0105-inch gage and must have 25 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts. Contact separation must be a minimum of .008 inch.

(5) *Make of make-before-break (D) combination contacts.*

(*a*) *Test.* The make of make-before-break (D) combinations must have 20 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If the relay does not meet these requirements, it must be readjusted to make on a .010-inch gage. Contact pressure must be 20 to 40 grams as above. Contact separation must be not less than .008 inch.

(6) *Make of make-before-break K combination contacts.*

(*a*) *Test.* The make of make-before-break (K) combinations must have 20 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If the relay does not meet these requirements, it must be readjusted to make on a .009-inch gage, but must not make on a .01-inch gage. The readjusted relay must have contact pressure of 20 to 40 grams. Contact separation must be not less than .008 inch.

(7) *Make contacts, armature backstop.*

(*a*) *Test.* On relays having only make (A) combinations, the armature backstop must be inspected to determine if a .007-inch gage will enter freely between the residual and the core, but a .013-inch gage should not enter freely.

(*b*) *Readjust* If readjustment is necessary, the backstop must be set so that a .009-inch gage enters freely between the residual and the armature, but a .011-inch gage does not enter freely.

(8) *Armature backstop.* On all other relays, except those having X contacts or limited travel, the armature backstop must be adjusted so that with the relay at normal, there will be a perceptible

clearance between the underside of the break contact springs and their spring pusher. This clearance must not exceed .007 inch.

b. X Combinations.

(1) All spring combinations except the (X) combinations must be adjusted as standard combinations and the pusher stops must be adjusted to hold the spring pushers in their normal unoperated position.

(2) The make contacts of (XC) and (XA) combinations must have 20 grams minimum make contact pressure when the armature is just striking the regular combination spring pusher. Proper contact separation must be maintained. If the relay does not meet these requirements, the combinations must be readjusted to make on a .02-inch gage, but must not make on a .023-inch gage.

(3) The armature backstop for preliminary operating (XA) combinations must be adjusted to provide a normal .008-inch minimum contact gap.

(4) With the relay at normal, the pusher of the (XA) spring must rest against the armature with approximately 10 grams of pressure. This pressure may be varied slightly, if necessary, to meet the electrical operating requirements for the (X) combination. However, the minimum pressure must be sufficient to restore the armature completely against the armature backstop.

(5) For the preliminary operating (XC) combination, the break contacts must open completely before the make contacts close. There should be a minimum perceptible contact follow of .010 inch as gaged by the eye. The break contacts must have 20 grams minimum contact pressure.

(6) Preliminary operating (XB) combinations must have 20 gram minimum contact pressure with approximately .01 inch contact follow as gaged by the eye, and have proper contact separation (.008 inch).

(7) For preliminary operating (XB) and (XC) combinations, the armature backstop must be adjusted so that, with the armature resting against the pusher stop, there will be a maximum clearance of .005 inch between the underside of the pusher and the armature. On (XC) combinations, the spring pusher may rest on the armature, provided the requirements given in (5) above are met.

c. L Combinations (Limited Travel).

(1) *Make contacts.*

(*a*) *Test.* All make contacts of (L) combinations must make on a .003-inch gage, but not on a .006-inch gage.

(*b*) *Readjust.* If the relay fails to meet these requirements, it must be readjusted to make on a .0045-inch gage, but not on a .0050-inch gage.

(2) *Break contacts.*

(*a*) *Test.* All break contacts must be inspected to not break on a .009-inch gage and must have 25 grams minimum and 40 grams maximum contact pressure.

(*b*) *Readjust.* If the relay fails to meet these requirements, it must be readadjusted to break on a .007-inch gage and must have 25 grams minimum and 40 grams maximum contact pressure. The break contact must open completely before the make contact closes. The minimum contact separation must be .004 inch.

(3) *Armature backstop.* The armature backstop must be adjusted to give .004 inch minimum and .01 inch maximum clearance between the underside of the break contact springs and their spring pusher.

d. M Combination Light Load, No Spring Stop.

(1) *Make contacts.*

(*a*) *Test.* Make contacts must make on a .008-inch gage, but not on a .014-inch gage and must have 25 gram minimum and 40 gram maximum contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If the relay fails to meet these requirements, it must be read-

justed to make on a .010-inch gage, but not on a .012-inch gage, having a minimum of 25 grams and a maximum of 40 grams contact pressure for each pair of twin contacts. Contact separation must be between .008 inch and .012 inch.

(2) *Break contacts.* Break contacts must open before make contacts close and must have a minimum of 25 grams and a maximum of 40 grams contact pressure.

(3) *Armature backstop.* The armature backstop must be adjusted so that with the armature at normal, there is a perceptible to .007-inch clearance between the break spring pushers and the armature.

e. F, G, J and Z Combinations.

(1) Relay spring pileups containing F, G, J and Z spring combinations are multiples of standard combinations of the A-type relay and should be adjusted accordingly.

(2) For example, the (F) combination is composed of a (D) and (K) combination. Each combination must be adjusted as covered in *a* above.

f. NA Combinations.

Note. An NA spring combination is a make (A) combination with additional preform pressure.

(1) NA spring combinations must be adjusted in the same manner as regular (A) combinations (*a* above).

(2) There must be a 25 gram minimum and a 40 gram maximum back pressure of the make and break contact springs on the spring pusher as measured at the contact.

(3) The break of (M) combinations must open completely before the make makes. The break contacts must have .01 inch minimum contact follow before breaking gaged by eye.

g. Relays Equipped With Large Single Contacts.

Note. Some A-type relays may be equipped with spring pileups consisting of standard (twin contact) spring combinations and a spring combination with large single contacts. The standard spring combination must be adjusted to meet applicable requirements as given in *a* above. The pusher stop must be adjusted to hold the spring pusher of the standard spring pileups in its normal nonoperated position.

(1) *Make contacts.*

(*a*) *Test.* All make contacts must make on a .003-inch gage but must not make on a .007-inch gage.

(*b*) *Readjust.* If the relay does not meet these requirements, it must be readjusted to make on a .0045-inch gage but not on a .0055-inch gage.

(2) *Break contacts.*

(*a*) *Test.* All break contacts must break on a .007-inch gage and must have 25 grams minimum and 40 grams maximum contact pressure.

(*b*) *Readjust.* If the relay does not meet these requirements, it must be readjusted to break on a .009-inch gage but not on a .012-inch gage. Contact pressure must be as stated in (*a*) above. Contact separation must be not less than .008 inch.

(3) *Make contacts, armature backstop.*

(*a*) *Test.* For those relays which have only (A) combinations, inspect the armature to determine that a .01-inch gage enters freely between the residual protection and the coil core but a .018-inch gage does not enter freely.

(*b*) *Readjust.* If readjustment is necessary, set the armature backstop so that a .012-inch gage enters freely and a .016-inch gage does not enter.

(4) *C combination, armature backstop.* For relays which have (C) combinations, set the armature backstop so that with the relay at normal there will be a perceptible clearance between the underside of the break contact springs and their spring pusher. However, this clearance must not be more than .007 inch.

h. Relays Equipped With Lever Arms.

Note. The contact gaging and backstop setting of A-type relays with lever arms (slow-to-release characteristic) are checked in the same manner as standard A-type relays, except that different gage values are used in inspecting and readjusting lever arm relays.

(1) *Make contacts.*

(*a*) *Test.* Make contact must make on a

.01-inch gage, but not on a .016-inch gage.

(*b*) *Readjust.* If the relay fails to meet these requirements, it must be readjusted to make on a .012-inch gage, but not on a .014-inch gage.

(2) *Break contacts.*

(*a*) *Test.* Break contacts must be inspected to break on a .019-inch gage and have a minimum of 25 grams and a maximum of 40 grams contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If the relay fails to meet these requirements, it must be readjusted to break on a .022-inch gage, but not on a .024-inch gage and must have a minimum of 25 grams and a maximum of 40 grams contact pressure for each pair of twin contacts. Contact separation must be not less than .008 inch.

(3) *Make of make-before-break (D) combination contacts.*

(*a*) *Test.* The make of make-before-break (D) combinations must be inspected to have a minimum of 20 grams and a maximum of 40 grams contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If the relay does not meet these requirements, it must be adjusted to make on a .025-inch gage and have a minimum of 20 grams and a maximum of 40 grams of contact pressure for each pair of twin contacts. Contact separation must be not less than .008 inch.

(4) *Make of make-before-break (K) combination contacts.*

(*a*) *Test.* The make of make-before-break (K) combinations are to be inspected to have a minimum of 25 grams and a maximum of 40 grams contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If the relay fails to meet these requirements, it must be readjusted so that the make of the (K) combination makes on a .023-inch gage, but not on a .025-inch gage and has a minimum of 25 grams and a maximum of 40 grams contact pressure for each pair of twin contacts. Contact separation must be not less than .008 inch.

(5) *Armature backstop.*

(*a*) *Test.* The backstop of relays having only (A) combinations must be inspected to determine if a .021-inch gage will enter freely between the residual projection and the coil core, but a .027-inch gage will not enter.

(*b*) *Readjust.* If the relay does not meet these requirements, adjust the armature backstop so that a .023-inch gage enters freely between the residual projection and the coil core, but a .025-inch gage does not enter. For relays having other than (A) combinations, the backstop must be adjusted so that there is a perceptible to .007 inch clearance between the underside of the break contact springs and their spring pusher. Contact separation must be not less than .008 inch.

183. General Requirements for Adjusting C-Type Relays

a. Armature Inspection. Ordinarily, the armatures do not require adjustment during the normal life of the relay. If the armatures have moved, inspect the positions of the armatures on the relay frame. If necessary, position them correctly and tighten the retaining screws.

b. Residual Projections. Inspect and readjust the residual projections, if necessary. The procedures for C-type relays are the same as for A-type relays (par. 181*b*).

c. Make Contact Gaging. To check and readjust the make contact gaging, if necessary, bend the armature slightly, with the armature and backstop adjusting tool. If the relay is badly out of adjustment due to damage, it may be necessary to bend the front end of the spring combination clamping plate with the clamping plate and armature backstop adjusting tool.

d. Break Contact Gaging. Ordinarily, once the make contacts have been adjusted, the break contacts will be in correct adjustment. If read-

justment is necessary, adjust the front end of the heavy break springs with the spring adjusting tool. Be careful not to damage the heavy spring stop. If the relay fails to meet its specified electrical requirements, adjust the tension springs with the spring adjusting or clamping plate and armature backstop adjusting tool. The tool selected will depend upon the thickness of the spring to be adjusted.

e. Armature Backstop. If necessary, adjust the armature backstop (par. 182) by bending the armature backstop with the armature and backstop adjusting tool.

184. Mechanical Specifications for C-Type Relays

a. General. Visually inspect the relay to make sure that the coil core screws and spring combination mounting screws are tight. Visually inspect the spring pushers and stops to make sure they are in the correct position in the spring combinations. In the operated position, a minimum air gap of .0065 between the armature and the frame should be checked.

b. Armature Residual. The method of adjusting the residual screw setting is given in paragraph 181*b*. The residual screw setting is inspected with the appropriate thickness gage held parallel to the pivot edge and inserted between the armature and coil core opposite the pivot edge. The gage must just clear the residual screw when the armature is manually operated.

(1) For residual projections specified as .010 inch or smaller, a gage .001 inch smaller must be loose when inserted between the armature and coil core and a gage .002 inch larger must be tight when inserted between the armature and the coil core.

(2) For residual projections specified as .011 inch or larger, a gage .002 inch smaller than .011 inch must be loose and a gage .002 inch larger than .011 inch must be tight when inserted between the armature and coil core.

(3) For relays which have release time or hold current requirements, the residual setting may be varied from that which is specified in order to obtain the desired operational characteristics. There must always be a perceptible residual gap and correct contact pressures must be maintained.

185. Contact Gaging Specifications and Armature Backstop Settings for C-Type Relays

a. Standard Lever Ratio Armatures for C-Type Relays. The specifications for C-type relays having standard ratio armatures with the bearing pins in the front position are listed below.

Note. The ratio of contact travel to the travel of the armature as measured at the centerline of the core is normally 2.5 to 1. This ratio is called the armature or lever ratio and is common to relays having standard ratio armatures.

(1) *Make contacts.*

(*a*) *Test.* All make contacts, except those of make-before-break and (X) combinations, must be inspected to make on a .005-inch gage, but not on a .009-inch gage.

(*b*) *Readjust.* If a relay does not meet these requirements, it must be readjusted to make on a .006-inch gage, but not on a .008-inch gage.

(2) *Break contacts.*

(*a*) *Test.* All break contacts, except those of make-before-break and (X) combinations, must be inspected to break on a .010-inch gage and to have a minimum of 25 grams and a maximum of 40 grams contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If a relay does not meet these requirements, it must be readjusted to break on a .011-inch gage, but must not break on a .013-inch gage and there must be a minimum of 25 grams and a maximum of 40 grams contact pressure for each pair of twin contacts.

(3) *Make of make-before-break (D) combination contacts.*

(*a*) *Test.* The make of make-before-break (D) combinations must be inspected to have a minimum of 20 grams and a maximum of 40 grams contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If a relay does not meet these requirements, it must be read-

justed to make on a .013-inch gage and to have a minimum of 20 grams and a maximum of 40 grams contact pressure for each pair of twin contacts. Proper contact separation must be maintained (.008 inch minimum).

(4) *Make of make-before-break (K) combination contacts.*

(*a*) *Test.* The make of make-before break (K) combinations must be inspected to have a minimum of 20 grams and a maximum of 40 grams contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If a relay does not meet these requirements, it must be readjusted to make on a .011-inch gage, but not on a .013-inch gage and have 20 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts. Proper contact separation must be maintained (.008 inch).

b. Slow-to-Release or Short-Lever Ratio Armatures. The specifications for relays having slow-to-release or short-lever ratio armatures with the bearing pin in the rear position are listed below.

Note. For relays equipped with a slow-to-release or short-lever ratio armature, the ratio of contact travel to the travel of the armature as measured at the centerline of the core is normally 1 to 1.

(1) *Make contacts.*

(*a*) *Test.* Make contacts must be inspected to make on a .008-inch gage, but not on a .013-inch gage.

(*b*) *Readjust.* If the relay does not meet these requirements, it must be readjusted to make on a .0095-inch gage, but not on a .0105-inch gage.

(2) *Break contacts.*

(*a*) *Test.* Break contacts must be inspected to break on a .016-inch gage and have 25 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If a relay does not meet these requirements, it must be readjusted to break on a .018-inch gage, but must not break on a .020-inch gage and have 25 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts.

(3) *Make of make-before-break (D) combinations contacts.*

(*a*) *Test.* The make of make-before-break (D) combinations must be inspected to have 20 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts.

(*b*) *Readjust.* If the relay fails to meet these requirements, it must be readjusted to make on a .021-inch gage and have 20 grams minimum and 40 grams maximum contact pressure for each pair of twin contacts. Proper contact separation must be maintained (.008 inch).

c. X Combinations. The specifications for relays having (X) combinations are listed below. (All the spring combinations except the (X) combinations must be adjusted as standard combinations and the pusher stops must be adjusted to hold the spring pushers in their normal positions) are listed below.

(1) The make contacts of (XA) and (XC) combinations must be inspected to have 20 grams minimum contact pressure when the armature is just striking the regular combination spring pusher. If required, the combination must be readjusted to make on a .027-inch gage, but not on a .031-inch gage and have proper contact pressure and separation.

(2) With the relay at normal, the pusher of the XA spring must rest against the armature with approximately 10 grams pressure. This pressure may be varied if necessary to meet the electrical operating requirements for the (X) combination. However, the mimimum pressure must be sufficient to completely restore the armature against the armature backstop.

(3) For preliminary operating (XC) combinations, the break contacts must open completely before the make contacts close and there must be a minimum .010 inch follow of the break contacts as gaged by the eye. The

break contacts must have a minimum of 20 grams contact pressure.

(4) Preliminary operating (XB) combinations must have a minimum of 20 grams contact pressure with approximately .010 inch contact follow as gaged by the eye and have proper contact separation.

d. Armature Backstop Setting, Make Combinations Only. On relays having only make combinations, the armature backstop must be adjusted in accordance with the specifications listed below.

(1) *Standard lever ratio armatures.*

(*a*) *Test.* For relays having standard lever ratio armatures, the armature backstop must be inspected to determine whether a .010-inch gage will enter freely between the residual projection and the coil core, but a .016-inch gage will not enter freely.

(*b*) *Readjust.* If the relay does not meet this requirement, readjust the backstop so that a .012-inch gage enters freely, but a .014-inch gage will not enter freely.

(2) *Slow-to-release short lever ratio armatures.*

(*a*) *Test.* For relays having slow-to-release short lever ratio armatures, the armature backstop must be inspected to determine whether a .017-inch gage will enter freely between the residual projection and the coil core, but a .025-inch gage will not enter freely.

(*b*) *Readjust.* If the relay does not meet these requirements, adjust the backstop so that a .019-inch gage enters freely between the residual projection and the coil core, but a .023-inch gage does not enter freely.

(3) On all other relays, except those having X contacts, the backstop must be adjusted so that with the relay at normal, there is a clearance perceptible to .008 inch between the underside of break contact springs and their spring pushers.

e. Armature Backstop Setting, (XA) Combinations. For preliminary operating XA combinations, the armature backstop must be adjusted to give a normal contact gap of .008 inch minimum.

f. Armature Backstop Setting, (XB) and (XC) Combinations. For preliminary (XB) and (XC) combinations, the backstop must be adjusted so that with the armature resting against its stop there is a minimum clearance of .005 inch between the underside of the pusher and the armature. On (XC) combinations, the spring pusher may rest on the armature, provided the requirements given in *c* above are met.

g. (F), (G), and (J) Combinations. (F), (G), and (J) combinations are multiples of other standard spring combinations and should be adjusted in accordance with those specifications.

h. (L) Combinations (Limited Travel). The specifications for relays having limited travel characteristics (armature bearing pin in front position on the armature) are listed below.

(1) *Make contacts.*

(*a*) *Test.* All make contacts of (L) combinations are to be inspected to make on a .005-inch gage but not on a .0075-inch gage.

(*b*) *Readjust.* If these requirements cannot be met, the relay must be readjusted to make on a .0065-inch gage, but not on a .007-inch gage.

(2) *Break contacts.*

(*a*) *Test.* All break contacts of (L) combinations are to be inspected so that they do not break on a .0105-inch gage and have a minimum of 25 grams and a maximum of 40 grams contact pressure.

(*b*) *Readjust.* If these requirements cannot be met, the relay must be readjusted to break on a .009-inch gage but not on a .010-inch gage. The contact pressure must be 25 to 40 grams and the minimum contact separation must be .008 inch. The break contacts must open completely before the make contacts close.

i. Relays Equipped with Large Single Contacts. Some C-type relays may be equipped with spring pileups consisting of standard (twin-contact) spring combinations and a spring com-

bination with large single contacts. The standard spring combination must be adjusted in accordance with the specifications listed in *a* above. The pusher stop must be adjusted to hold the spring pusher of the standard spring pileup in its normal nonoperated position. The pileup with large single contacts must be adjusted to meet the specifications in (1) and (2) below.

(1) *Make contacts.*

(*a*) *Test.* All make contacts are to be inspected to make on a .005-inch gage but not on a .009-inch gage.

(*b*) *Readjust.* If the relay does not meet these requirements, it should be readjusted to make on a .006-inch gage but not on a .0075-inch gage.

(2) *Break contacts.*

(*a*) *Test.* All break contacts are to be inspected to break on a .011-inch gage and must have a minimum of 30 grams and a maximum of 50 grams contact pressure.

(*b*) *Readjust.* If the relay does not meet these requirements, it must be readjusted to break on a .013-inch gage but not on .016-inch gage. Contact pressure must be as stated in *a* above and contact separation must be not less than .008 inch.

186. Electrical Adjustments for A- and C-Type Relays

a. After all mechanical adjustments are completed, the electrical operation of the relay should be checked in accordance with the specifications listed in the applicable relay adjustment table.

b. The relays should be checked with the values given in the "Readj. ma." column.

c. If outside these limits proceed as described in (1) through (4) below to adjust the relay:

(1) If the relay operates on the nonoperate value, increase the tension on the force springs.

(2) If the relay fails to operate on the operate value, decrease the tension on the force springs.

(3) If the adjustments cannot be made by adjusting the tension of the force springs, carefully adjust the tension of the movable springs.

(4) If the hold or release adjustments cannot be made by adjusting the springs, the setting of the residual screw may be changed but the residual projection must be perceptible at all times.

187. Replacement of Spring Pushers and Pusher Stops, A- and C-Type Relays

a. Replacement of Spring Pushers. Figure 93 illustrates the use of the proper relay spring tool. The procedure for removal and replacement of the pusher is listed in (1) through (10) below.

(1) Remove the relay from the circuit plate.

(2) Count the hooks on the spring pusher and select the relay spring tool with a corresponding number of fingers.

Note. Each of the two relay spring tools has four different finger combinations. Be sure to use the tool that has the same number of fingers as there are hooks on the spring pusher.

(3) Insert the proper finger combination of the relay spring tool under the light springs. Position the extended tips of the relay spring tool in the spring pusher hook slots of the pusher to be removed (A, fig. 94).

(4) Hold the spring pusher in position and lift the light springs to clear the pusher hooks. Slide the spring pusher toward the back of the relay until the pusher hooks clear the light springs.

(5) Release the light springs, turn the relay over, and the spring pusher will drop out through the clearance slot in the clamping plate.

(6) Drop a new spring pusher (the same type and number of hooks) into the clearance slot in the clamping plate (fig. 93). Be sure the spring pusher is properly positioned.

(7) Insert the relay spring tool under the light springs (B, fig. 94) with the extended tips in back of the spring pusher.

(8) Hold the spring pusher in position and lift the light springs, sliding the spring pusher forward.

(9) Release the light springs and remove the relay spring tool.

(10) Replace the relay on its circuit plate.

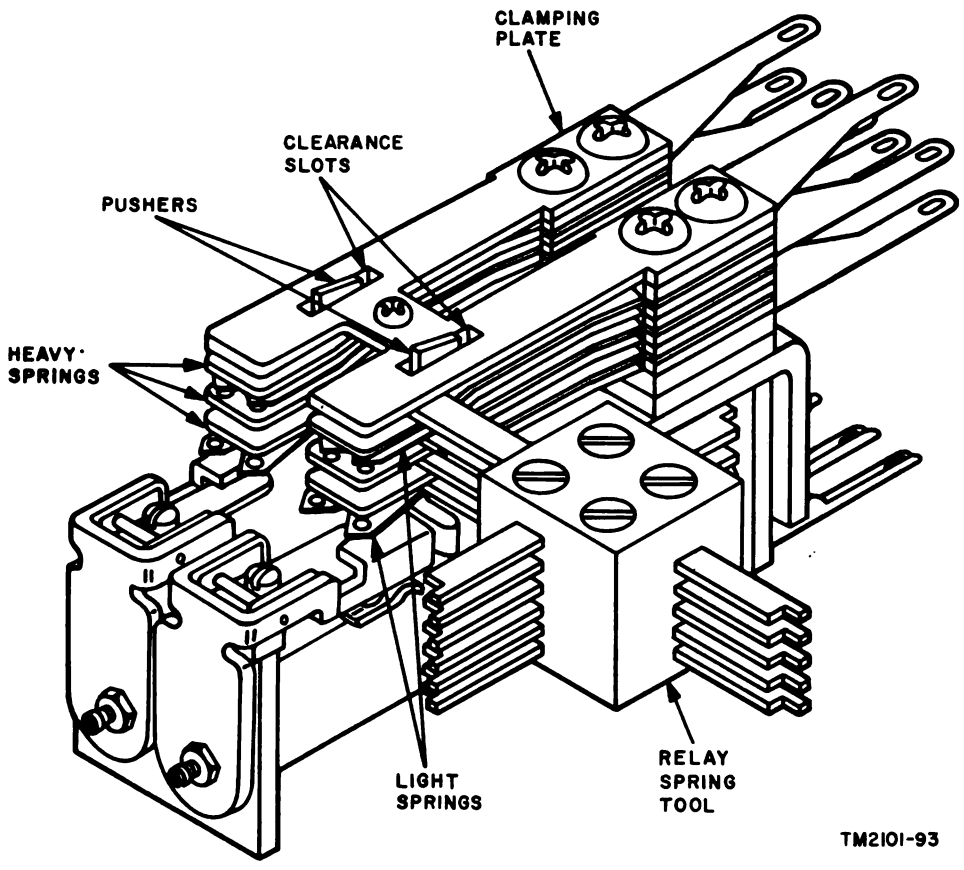


Figure 93. Tool location for removal of pushers.

b. Removal and Replacement of Stops. Figure 95 illustrates the use of the relay spring tool. The procedure for removal and replacement of the stops is listed below.

(1) Remove the relay from its circuit plate.
(2) Remove the spring pusher as described in *a* above.
(3) Remove the clamping plate screw (located between the clearance slot) and spacer of the spring pileup.
(4) Insert a screwdriver between the spring pileups and remove the mounting plate screw.
(5) Lift the spring pileup and mounting plate from the relay frame.
(6) Count the hooks on the stop and select the relay spring tool which has the corresponding number of fingers.
(7) Insert the relay spring tool with the proper finger combination above the heavy springs (A, fig. 96) with the extended tips in front of the pusher stop.
(8) Push down on the heavy springs until they clear the stop hooks. Slide the pusher stop toward the back of the relay with the relay spring tool.
(9) Slide the pusher stop out of the clearance slot in the bottom of the spring pileup.
(10) Remove the relay spring tool.
(11) Insert a new pusher stop (the same type and number of hooks) into the clearance slot in the bottom of the spring pileup.
(12) Insert the relay spring tool with the proper number of fingers above the heavy springs, with the extended tips in back of the stop (B, fig. 96).
(13) Hold the heavy springs down with the relay spring tool and slide the stop forward and remove the relay spring tool.
(14) Place the spring pileup and the mounting plate in the proper position on the relay frame.

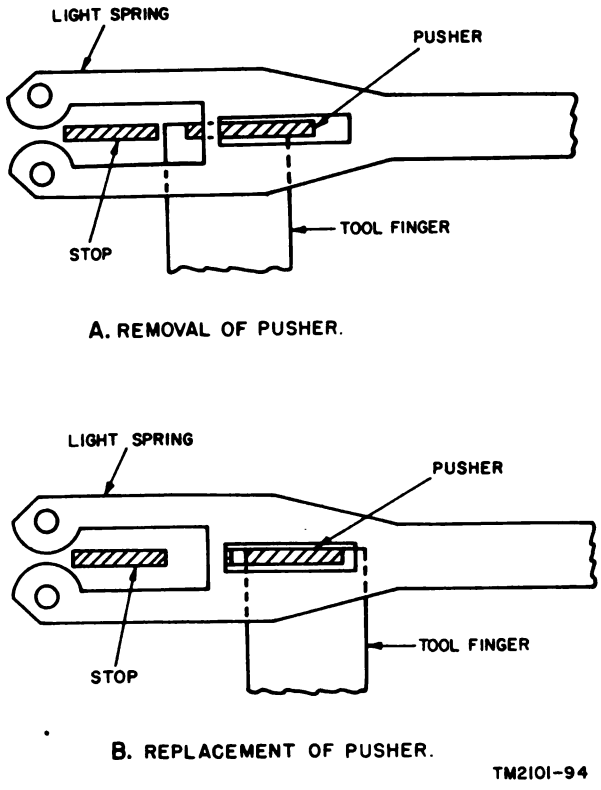


Figure 94. Tool finger positions for removal and replacement of pushers.

(15) Replace the mounting plate screws.

(16) Replace the clamping plate front screw and spacer.

(17) Replace the spring pusher as described in *a* above.

(18) Replace the relay on the circuit plate.

188. Disassembly and Reassembly of A- and C-Type Relays

The disassembly and reassembly instructions for A- and C-type relays are presented in step-by-step order. Repair personnel should study the procedures and the associated exploded views. Familiarity with these procedures will enable personnel to replace a particular component part without necessarily following the same order of disassembly and reassembly described in this manual.

a. Removal and Disassembly of A-Type Relay (fig. 97). The faulty A-type relay should be removed from its circuit plate and disassembled in accordance with the procedure listed below.

(1) Remove the clamping plate screw (1) and spacer (2).

(2) Remove the mounting plate screw (3)

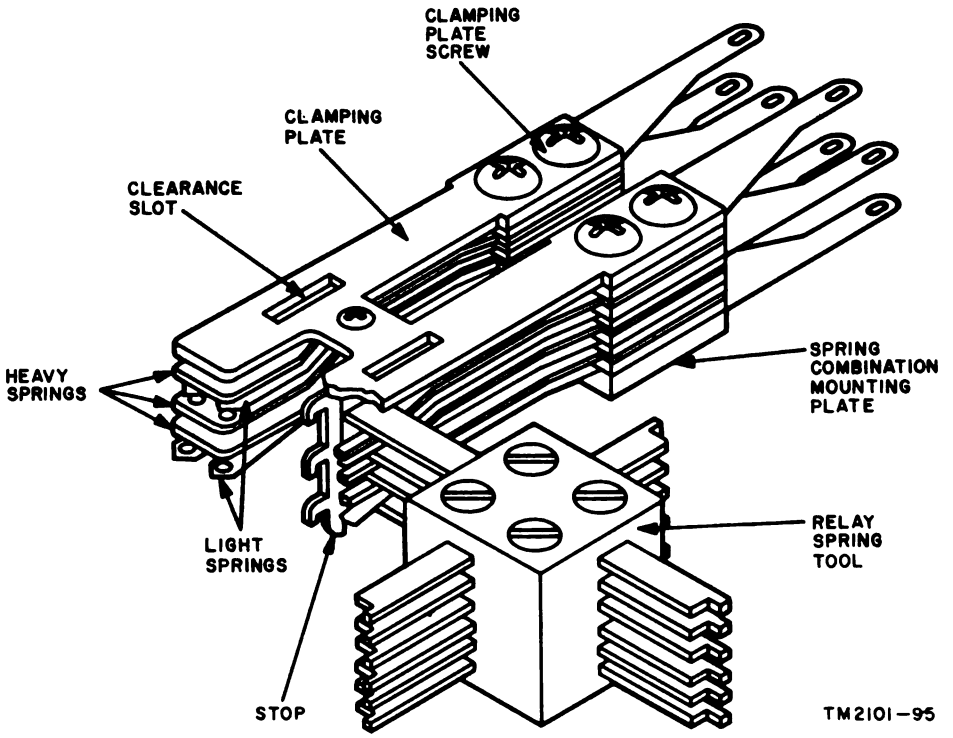
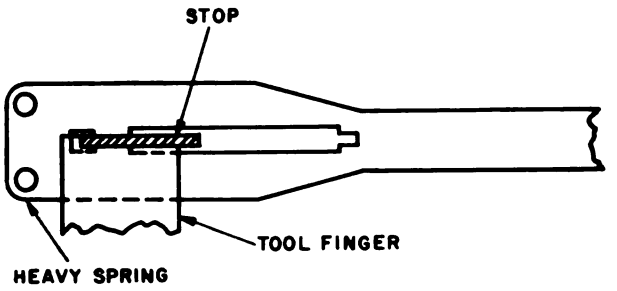
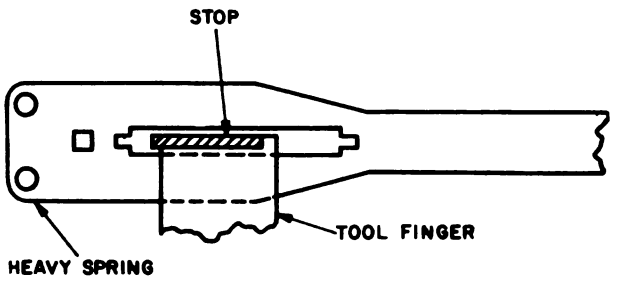


Figure 95. Tool location for removal of stops.



A. REMOVAL OF STOP.



B. REPLACEMENT OF STOP.

TM2101-96

Figure 96. Tool finger positions for removal and replacement of pusher stops.

and remove the spring pileup (4) from the frame (5).

(3) Remove the armature assembly, which consists of the armature support plate (6) and armature residual plate (7), from under its spring retainer clip (15).

(4) Remove the armature support plate from the armature residual plate by removing the armature support plate mounting screw (8).

(5) Remove the armature residual screw and nut (9 and 10).

(6) Remove the coil mounting nut and washer (11 and 12) from the coil mounting stud (13).

(7) Remove the coil (14) from the frame.

b. Reassembly and Replacement of A-Type Relay. The reassemble and replacement procedures for the A-type relay are listed below.

(1) Insert the coil mounting stud (13) into the frame (5).

(2) Slip the coil mounting washer and nut (11 and 12) on the coil mounting stud (13) and tighten the coil mounting nut.

(3) Thread the armature residual screw (9) through the armature residual nut (10).

(4) Insert the armature residual screw through the armature residual plate (7) so that the residual screw just protrudes on the inner face of the residual plate and tighten the armature residual nut (holding the armature residual screw) against the armature residual plate.

(5) Reassemble the armature support plate (6) and armature residual plate into an armature assembly by inserting and tightening the armature support plate mounting screw (8).

(6) Insert the assembled armature assembly under its spring retainer clip (15) onto the frame.

(7) Hold the spring pileup (4) on the top of the frame.

(8) Insert the mounting plate screw (3) and tighten down on the frame.

(9) Insert the clamping plate screw (1) through the clamping plate and the spacer (2) and tighten down on the frame.

(10) Replace the relay on its circuit plate.

(11) Adjust the relay before returning it to service.

c. Removal and Disassembly of C-Type Relays (fig. 98). The faulty C-type relay should be removed from its relay circuit plate and disassembled in accordance with the procedure listed below.

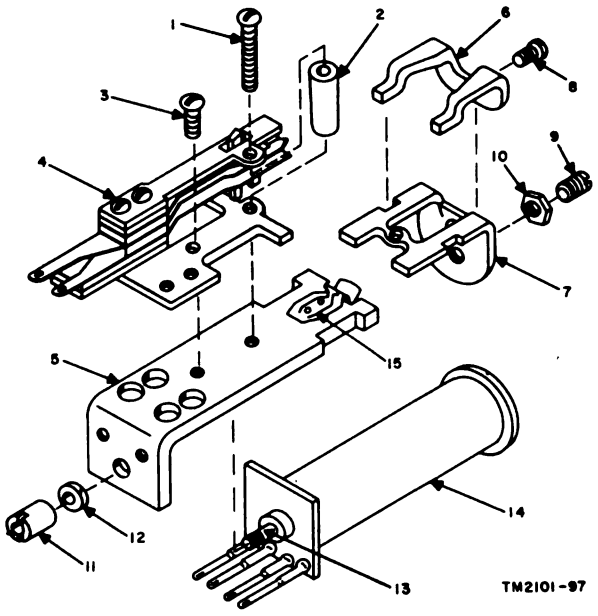
(1) Remove the clamping plate screw (1) and spacer (2).

(2) Remove the mounting plate screw (3) and remove the spring pileup (4) from the frame (5).

(3) Remove the two armature mounting screws (6).

(4) Remove the two armature assemblies (7) from the frame.

(5) Remove the armature residual screw



1 Clamping plate screw
2 Spacer
3 Mounting plate screw
4 Spring pileup
5 Frame
6 Armature support plate
7 Armature residual plate
8 Armature support plate mounting screw
9 Residual screw
10 Residual nut
11 Coil mounting nut
12 Coil mounting washer
13 Coil mounting stud
14 Coil
15 Spring retainer clip

Figure 97. A-type relay, exploded view.

and nut (8 and 9) from the armature assembly.

(6) Remove the two coil mounting screws (10) from the frame.

(7) Remove the two coils (11).

d. Reassembly and Replacement of C-Type Relays. The reassembly and replacement procedures for C-type relays are listed below.

(1) Insert each of the two coils (11) under the frame (5).

(2) Insert each of the two coil mounting screws (10) through the frame into the tapped end of the coil core and tighten the coil mounting screw.

(3) Thread the armature residual screws (8) through the armature residual nut (9).

(4) Insert the armature residual screw through the armature residual plate so that the residual screw just protrudes on the inner face of the residual plate.

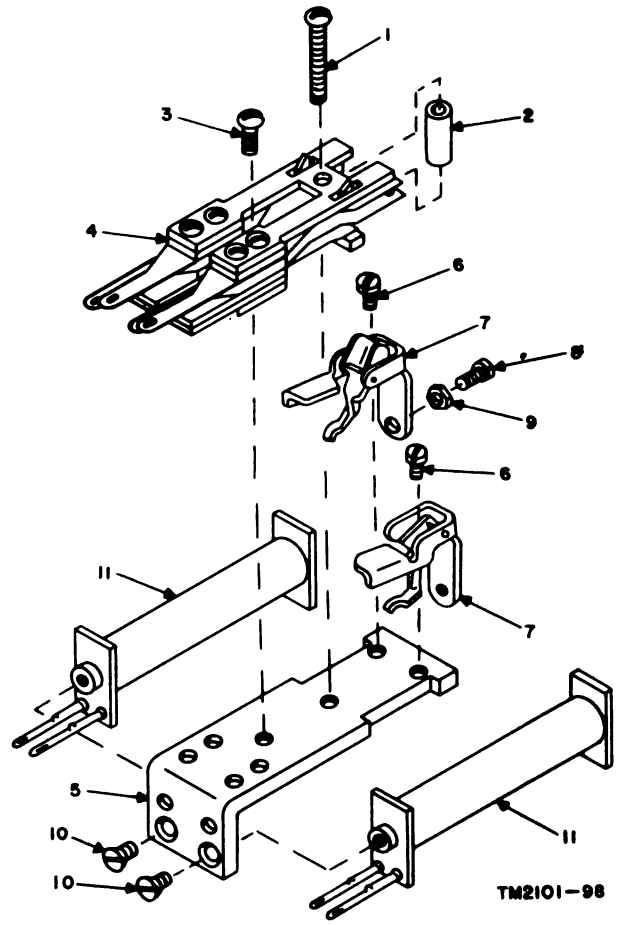
(5) Hold the armature residual screw and tighten the armature residual nut against the residual plate.

(6) Place the two armature assemblies (7) on the frame.

(7) Insert each of the two armature mounting screws (6) and tighten down on the frame.

(8) Place the spring pileup (4) on top of the frame.

(9) Insert the mounting plate screw (3) and tighten down on the frame.



1 Clamping plate screw
2 Spacer
3 Mounting plate screw
4 Spring pileup
5 Frame
6 Armature mounting screw (2)
7 Armature assembly (2)
8 Armature residual screw
9 Armature residual nut
10 Coil mounting screw (2)
11 Coil (2)

Figure 98. C-type relay, exploded view.

(10) Insert the spacer (2) and push the clamping plate screw (1) through the clamping plate and the spacer and tighten down on the frame.

(11) Replace the relay on its circuit plate.

(12) Adjust the relay before returning it to service.

Section IV. RELAY ADJUSTMENT TABLES

189. General

The relay adjustment (RA) tables supplied in this section contain the information necessary for testing and adjusting the relays for electrical operation. The Stromberg-Carlson Type 6–B, Current-Flow Test Set (TM 11–2112) is used to check the operate, nonoperate, release, and hold current requirements listed on the applicable relay adjustment tables. The RA tables are used when performing the tests and adjustments outlined in paragraph 181 through 187.

190. Relay Testing Using RA Tables

a. Tables. A separate RA table is provided for each circuit in the XY dial central office. The data in the columns of the RA tables are discussed in (1) through (11) below.

(1) *Relay.* This column lists the relays in the circuit by their functional designations. For example, the designation FB means *finder busy,* SW means *switch-through,* ST means *start,* etc.

(2) *Manufacturer's Part No.* This column lists and identifies each relay by the Manufacturer's (Stromberg-Carlson) stock number.

(3) *Resid (inch).* This column lists the minimum operated air gap for each relay. The air gap is determined by the projection of the residual screw.

(4) *Block or insulate.* This column provides necessary instructions for preparing the relay for testing. For example, when checking the electrical operation, it may be necessary to block another relay (operated or nonoperated) or to insulate a pair of contacts.

(*a*) *Block.* For example, if the notation RD(O) appears in this column, block the RD relay (operated) by inserting a toothpick underneath the armature backstop. If the notation RD(NO) appears, block the relay (nonoperated) by inserting a toothpick between the core and the armature. Be sure to remove the toothpicks when testing is completed.

(*b*) *Insulate.* For example, if the notation RD (25,26) appears in this column, insulate contact 25 from 26 on the RD relay by inserting a piece of bond paper between them. Be sure to remove the paper after completing the test.

(5) *Test with (see note).* This column provides reference to one or more of the notes listed below.

(*a*) *Note 1.* Battery and ground are supplied by the circuit plate to the two-winding relay bieng checked. The two windings are connected in series and are aiding. This setup is used to check battery ground feeds.

(*b*) *Note 2.* X magnet in series.

(*c*) *Note 3.* Y magnet in series.

(*d*) *Note 4.* Release (Z) magnet in series.

(*e*) *Note 5.* Battery is supplied by the circuit plate but the current-flow test set must be adjusted to supply ground. This setup is used to check battery connected relays.

(*f*) *Note 6.* Ground is supplied by the circuit plate, but the current-flow test set must be adjusted to supply battery. This setup is used to check ground connected relays.

(*g*) *Note 7.* Current-flow test set is adjusted to supply battery and ground. This setup is used to check relays which are not normally connected to either battery or ground.

(*h*) *Note 8.* Relay winding is energized as indicated during test.

(*i*) *Note 9.* Residual projection is varied to meet required currents. The minimum projection should be per-

ceptible to the eye. The maximum projection is .004 inch.

(*j*) *Note 10.* Disconnect XY switch before making current-flow test.

(6) *Test set point.* This column lists the relay terminals to which alligator clips of the test set cords are connected.

(*a*) If one point is specified, the alligator clip is attached to that terminal only. For instance, if the notation CB(5) appears, this means that the alligator clip is attached to terminal No. 5 of the CB relay.

(*b*) If two points are specified, one alligator clip is attached to each of the two terminals noted. For instance, if the notation SW(6,9) appears, one alligator clip is attached to terminal No. 6 and the other to terminal No. 9 on relay SW.

(7) *Test wdg.* This column designates the winding through which current flows during the test.

(8) *Test for.* Four designations can appear in this column; O (operate), NO (nonoperate), H (hold), and R (release). Each designation is accompanied by current values in the *Readjust ma* (milliamperes) and *Test ma* columns.

(*a*) When the indicated value of current for O is flowing through the winding, the relay should operate.

(*b*) When the indicated value of current for NO is flowing through the winding, the relay should not operate.

(*c*) When the indicated value of current for H is flowing through the winding (after the current has been reduced from the operate value), the relay should remain operated.

(*d*) When the indicated value of current for R is flowing through the winding (after the current value has been reduced from the operate value), the relay should release.

(9) *Readj ma.* This column indicates the value of current to which the relay must be adjusted if the relay does not meet the requirements in *Test ma* column.

(10) *Test ma.* This column lists the current value applied to the relay under test. If after testing with the *Test ma* current value, no further adjustments are required, the information in (9) above is disregarded. If the relay requires adjustment, apply the *Readj ma* current value and adjust as indicated.

(11) *Remarks.* This column lists other pertinent information.

b. Adjusting Procedure. The operating instructions to be followed when using the RA tables with the current-flow test set are listed below.

(1) The instructions for use of the test set are contained in TM 11–2112. In addition, observe the instructions below.

(*a*) Battery and ground must be connected to the circuit plate.

(*b*) The circuit in which the relay appears must be idle.

(2) Use the applicable RA tables (par. 191) and proceed as follows:

(*a*) Test the relay with the test current specified.

(*b*) Check the electrical requirements in the RA tables. If the mechanical adjustment is correct, the relay should function properly in the circuit.

(*c*) If the relay does not operate properly on the test values readjust the relay to meet the readjust values specified.

(*d*) If the relay does not meet the readjust values, check the mechanical adjustments in paragraphs 181 through 185.

191. RA Tables

The RA tables listed below are grouped according to their equipment identification. The schematic diagrams which should be used when testing the relays using the current-flow test set and RA tables are referenced in paragraph 28.

a. Switching Circuits.

(1) *Line circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
LR	369560	.004	LR(1, 2) (3, 4)	5	CO(26)	A–B	O	19.5	21.5	
							NO	16.5	15	
CO	369560	.004	----------	5	LR(5)	C–D	O	24	27	
							NO	20	18	
							O	12	13	X contact only.
							NO	9	8	X contact only.

(2) *Linefinder-allotter circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
ST	359500	.004	ST(1, 2)	5	ST(A)	A–B	O	40	43	Type C relay.
							NO	33	30	
SW	359500	.004	SW (34, 35)	5	SW(C)	C–D	O	29	31	Type C relay.
							NO	24	22	
PA	352016	.006	----------	5	YS–3	A–C	O	50	55.5	***Caution:*** **When checking relay in either half of the allotter, that half should be busied out.**
YS	352003	.004	YS (9, 10)	5	YS(B)	B–D	O	14.5	16	
							NO	12.5	12	
							H	7	7.5	
XS	352004	.004	XS(5, 6)	5	XS(23)	A–C	O	42	46	Special adjustment required as follows: *a.* Adjust K combination to make on .008-inch gage and not on .009-inch gage. *b.* Inspect for minimum of 30 grams pressure on break of K combination. *c.* Inspect K combination for minimum of .004-inch contact gap with relay operated. *d.* Short spring of K combination rests against pusher with maximum pressure of 15 grams.
YD	352005	.005	----------	5	YD(2)	A–C	O	21	23	
							NO	17.5	16	

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
GD	352006	.004	GD (21, 22) (23, 24) (1, 2) (31, 32)	5	SA(8)	A–C	O NO	23 18	25 16	Negative battery is on RX magnet.
SA	352007	.004	SA(3, 4) (1, 2) (5, 6) FB (27, 28)	5	FB(28)	A–C	O NO	10 8	11 7	
FB	352009	.004	FB (21, 22) (5, 6) (23, 24) (25, 26)	5	FB(A)	A–C	O NO	8.5 6.5	9.5 5.5	Disconnect wire from terminal (A) before making current flow tests.
PU	352010	.004	PU (25, 26)	5	YD(7)	A–C	O NO	25.5 19	28 17.5	
AS	352011	Note 9	YS(5, 6)	5	YS(5)	A–C	O NO	23 17	25 15	
TF	352012	.004	TF (25, 26) (28, 29)	5	TF(A)	A–C	O NO	18 14.5	20 13	Disconnect wire from terminal (A) before making current flow tests.

(3) *Nondigit-canceling selector circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
SW	352107	.004	SW(1, 2)	7 & 9	SW(A, C)	A–C	O NO	21 16	23 14.5	
CB	352022	.005	CB(1, 2)	5 & 9	SW(26)	B–D	O NO	31 29	32 28	Limited travel relay.
RD	358821	Note 9	RD(3, 4)	5 & 9	CB(5)	A–D	O H R	34 10 8	37 11 7	
XD	358824	.004	RD(NO)	5	CB(5)	B–D	O NO	34 26	37 24	

HA	352026	.007	----------	7 & 9	HA(A, C)	A–C	O	98	106	Limited travel relay: Adjust springs No. 1 & 3 for 25 to 40 grams back pressure on pusher hook (measured at the contact) with relay in unoperated position.

(4) *Digit-canceling selector circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
SW	352148	.004	----------	7 & 9	RD(3)	A–C	O	24	26	Adjust make of D combination on .013-inch gage.
					XD(22)		NO	13.5	12	
CB	352022	.005	RD(NO) XD(NO) SW(25, 26) (28, 29)	1	SW(25, 28) CB(5)	A–C, B–D	O NO	15.5 14.5	16 14	Limited travel relay.
RD	358803	Note 9	RD (21, 22)	5 & 9	CB(5)	A–D	O H R	41 10 8	45 11 7	
XD	358824	.004	----------	5 & 9	DC(34)	B–D	O NO	34 26	37 24	
HA	352026	.007	----------	7 & 9	HA(A, C)	A–C	O	98	106	Limited travel relay: Adjust springs No. 1 & 3 for 25 to 40 grams back pressure on pusher hook (measured at the contact) with relay in unoperated position.
							NO	82	76	
DC	359517	.004	RD(5, 6)	5	DC(C)	C–D	O NO	28 21	30 19	Type C relay.
DA	359517	.004	RD(5, 6)	5	DA(A)	A–B	O NO	39 27	43 25	Type C relay.

										Operate busy key before making current flow tests.
AB	352001	.008	CB(NO)	5, 9	SW(10)	B–D	O	50	53	
							NO	44	42	
							R	14	12	
CB	352000	.006	----------	1, 9	CB(C, B)	A–C	O	18.5	19.5	Limited travel relay.
						B–D	NO	15.5	14.5	
RE	368800	Note 9	----------	5, 9	CB(5)	A–D	O	41	45	
							H	10	11	
							R	8	7	
XD	358801	.004	----------	5	BT(8)	B–D	O	34	37	
							NO	25	23	
RT	352002	Note 9	SW (29, 30)	5	RT(6)	A–C	O	84	89	
							NO	58	52	
							O	30	31.5	X contact only.
							NO	25	23	X contact only.
BT	352227	.008	BT(1, 2)	5	BT(2)	A–C	O	20	21.5	
							NO	15	14.5	
SW	352013	.004	----------	7	BT(9)	B–D	O	85	92	
					XD(22)		NO	74	68	
							O	27	29	X contact only.
							NO	23	21	X contact only.

(6) *XY PBX connector circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
CT	352020	.004	----------	7 & 9	AB(23)	A–C	O	21	23	
					CT(C)		NO	17	15.5	
AB	352021	.006 ±.002	RD(5, 6)	5 & 9	ER(23)	B–D	O	50	53	
							NO	44	42	
							R	14	12	
CB	352022	.005	RD(NO)	1	CB(C, B)	A–C, B–D	O	15.5	16	Limited travel relay.
							NO	14.5	14	

RD	358800	Note 9	SW (31, 32) YD(NO) XD(NO)	5	CB(5)	A–D	O	41	45	
							H	10	11	
							R	8	7	
XD	368802	.004	BT (26, 27)	5	BT(27)	A–C	O	49	54	
							NO	34	31	
YD	358804	.004	----------	5	RT(2)	B–D	O	84	91	
							NO	63	58	
HA	352026	.007	----------	5	SW(28)	A–C	O	98	106	
							NO	82	76	
ER	358806	.004	BT(NO)	6	XD(2)	A–C	O	52	55	
							NO	40	36	
RT	352024	.004	----------	7	ER(8)	A–C	O	80	88	Disconnect wire or wires from terminal (C) before making current flow tests.
					RT(c)		NO	61	55	
							O	30	31.5	X contact only.
							NO	25	23	X contact only.
BT	352438	.007	----------	5	SW(11)	B–D	O	24–5	25.5	
							NO	21	19	
SW	352028	.004	YD (21, 22)	7	YD(21)	B–D	O	98	105	
					BT(5)		NO	85	78	
							O	27	29	X contact only.
							NO	23	21	X contact only.

(7) *Individual line connector circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
AB	352021	.006 ±.002	XD(NO)	5	SW(7)	B–D	O	50	53	
							NO	44	42	
							R	14	12	
CB	352022	.005	RD(NO)	5	AB(3)	B–D	O	31	32	Limited travel relay: Adjust backstop clearance between pusher and swinger of B or C combination for minimum of .005 inch and maximum of .009 inch with relay in unoperated position.
							NO	29	28	
RD	358800	---------	XD(NO)	5	CB(5)	A–D	O	41	45	
							H	10	11	
							R	8	7	

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
XD	358813	.004	----------	5	RD(5)	B–D	O	40.5	43.5	
							NO	30.5	28.0	
RT	352054	.004	----------	5 & 9	RT(2)	B–D	O	32	34.5	
							NO	26.5	24	
							O	13	14	X contact only.
							NO	11	10	X contact only.
BT	352225	.088	RT (21, 22)	5	XD(25)	A–C	O	27	29	
							NO	22	20	
SW	352056	.004	RT (21, 22)	7	BT(23)	B–D	O	66	72	
							NO	53	47	
			XD (21, 22)		XD(22)		O	27	29	X contact only.
							NO	23	21	X contact only.

(8) *Individual line and trunk hunting connector circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
AB	352021	.008 ±.002	XD(NO); YD(NO)	5	SW(21)	B–D	O	50	53	
							NO	44	42	
							R	14	12	
CB	352022	.005	----------	9.1	CB(C–B)	A–C, B–D	O	15.5	16	Adjust make of D combination on .013-inch gage.
							NO	14.5	14	
RD	358800	Note 9	----------	9.5	CB(5)	A–D	O	41	45	
							H	10	11	
							R	8	7	
XD	358814	.004	----------	5.9	HA(6)	A–C	O	45	49	
							NO	33	30	
YD	358850	.004	----------	5.9	E(23)	B–D	O	47	51	
							NO	32	29	
HA	352062	.007	----------	9.7	E(1); E(11)	A–C	O	78	85	Limited travel relay: Adjust springs No. 1 & 3 for 25 to 40 grams back pressure on pusher hook (measured at the contact), with relay in unoperated position.
							NO	64	57	
RT	352063	.004	----------	7	RT (8, C)	A–C	O	62	67	
							NO	52	48	

							O	30	31.5	X contact only.
							NO	25	23	X contact only.
BT	352234	.008	RT(3, 4)	5	XD(3)	A–C	O	32	34	
							NO	27	25	
SW	352065	.004	RT(3, 4)	9.7	XD(26)	B–D	O	82	89	
			XD		BT(23)		NO	68	61	
			(25, 26)				O	27	29	X contact only.
							NO	23	21	X contact only.

(9) *Trunk circuit (2,000 ohms or less).*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
RS	352017	.004	SW(NO)	7	SW(27)	A–C	O	2	2.5	
			SR1		SR1		NO	1.5	1	
			(29, 30)		(30)					
SR1	352018	.004	RD(5, 6)	5	SR(8)	A–C	O	25	27	
			(25, 26)				NO	17	15.5	
SR	352161	Note 9	SR1 (NO)	5	SR(D)	B–D	O	9.5	10	
							NO	8	7.5	
							H	4	4.5	
SW	352023	.004	----------	5	SW(B)	B–D	O	37	40	
							NO	25	23	
							O	12	13.5	X contact only.
							NO	8.8	7.2	X contact only.
SH	358805	.004	----------	5	SR1(5)	A–C	O	36.6	40.5	
							NO	21.4	19	
CB	352153	.005	RD(NO)	1	SR(3, 6)	A–C,	O	15.5	16	Limited travel relay.
						B–D	NO	13.5	13	
RD	358803	Note 9	SR1	5	SR1(8)	A–D	O	41	45	
			(29, 30)				H	10	11	
			CB(5, 6)				R	8	7	

(10) *Trunk circuit (3,000 ohms or less).*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
PL	352327	.004	RD2(NO)	1	SR2 (5, 8)	A–C, B–D	O	7	7.5	Limited travel relay.
			SR2(5, 7) (8, 10)				NO	5.5	5	
SR2	352332	.004	RD1 (5, 6)	7	PL(2) SR2(A)	A–C	O	58	63	Disconnect wire or wires from terminal SR2(A) before making current flow tests.
							NO	48	44	
							H	28	30	
SH	352165	Note 9	----------	5	SW2(9)	A–C	O	22	24	
							NO	14.5	13	
SW2	352588	.004	SR2(1, 2)	5	RD2(4)	A–C	O	22	24	
							NO	17	15	
RD2	358912	.004	SR2(3, 4)	5	PL(5)	A–D	O	31	34	
							H	10	11	
							R	6	7	
PC1	352329	.004	----------	5	PC1(A)	A–C	O	21	23	Disconnect wire or wires from terminal PC–1(A) before making current flow tests.
							NO	17	15	
SW1	352330	.004	----------	5	RD1 (22)	A–C	O	17	19	
							NO	13.2	11.4	
PC2	352331	.004	----------	7	PC1(5) RD(2)	A–C	O	75	83	
							NO	57	51	
RS	352017	.004	RD(NO)	7	RV(23) RS(C)	A–C	O	2	2.5	
							NO	1.5	1	
RD1	358828	Note 9	RV (21, 22) SW1(NO) PC2(3, 4)	5	RS(2)	A–D	O	40	44	
							H	10	11	
							R	8	7	
SH1	358857	.004	----------	5	SW2(7)	A–C	O	49	53	
							NO	35	33	
RV	352333	.004	CB(3, 4)	5	SR1(2)	A–C	O	14	15	
							NO	10.5	9.5	
SR1	352334	.004	RV(NO)	5	SR1(D)	B–D	O	16.3	16.8	
							NO	14.7	13.7	
							H	7.3	7.9	

CB	352022	.005	RD1(NO) SW(5, 6) PC2 (5, 6)	1	RV(5, 24)	A–C, B–D	O NO	15.5 14.5	16 14	Limited travel relay.

(11) *Combination trunk circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
RU1	358916	.004	SR1(NO) RU(1, 2) SL (23, 24)	5	RU1(30)	A–C	O NO	50 38	55 35	***Caution:*** **Battery on SL (5, 6).**
SL	352597	.004	----------	6	SL(C)	A–C	O	13	14	Disconnect wires from terminal SL(C).
							NO	11	10	***Caution:*** **Battery on SL (5, 6).**
							O	6	6.5	X contact only.
							NO	5	4.5	X contact only.
RD11	352257	.004	----------	5	SH(3)	A–C	O	12	13	***Caution:*** **Battery on RD11(4).**
							NO	10	9	
RD1	352261	.004	CB(3, 4)	5	SL(21)	B–D	O	39	42	***Caution:*** **Battery on RD1 (5, 23).**
							H	16	17.5	
							O	13	13.8	X contact only.
							NO	11	10	X contact only.
CB	352000	.006	RD(NO)	1	RU1 (12, 33)	A–C, B–D	O NO	18.5 15.5	19.5 14.5	Limited travel relay.
RD	358845	Note 9	CB(3, 4) SL (21, 22)	5	CB(5)	A–D	O H R	44 10 8	48 11 7	
SH	358917	.004	SR(NO)	5	RD(4)	A–C	O NO	44 32	48 29	
SR	352268	.004	SR1(NO)	7	SR(A, C)	A–C	O	16.5	17.5	Disconnect wires from terminals (A, C) before making current flow tests.
							NO	11	10	
SR1	352598	.002	----------	5	SR(2)	A–C	O	28	31	***Caution:*** **Battery on SR1(8).**
							NO	23	21	
							O	11.5	12.5	X contact only.
							NO	9.5	8.5	X contact only.
RU	352157	.004	RU1(NO)	7	RU(A, C)	A–C	O	2.6	2.8	Adjust contact gap for .010 ± .002 inch and contact pressure to 30 ± 10 grams. No contact gaging required.
							NO	2	1.7	

(12) *Information trunk circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
SL	352573	.004	SL1(NO) RD(NO)	6	SL(C)	A–C	O NO	35 30	38 27	
CB	352574	.004	RD(NO)	1	SL(1, 3)	A–C, B–D	O NO	13 10.5	14.5 9.5	
RD	358811	.004	SL1 (5, 6) (3, 4)	5	CB(5)	A–D	O H R	36 10 8	39 11 7	
SL1	358812	Note 9	RD (23, 24)	5	SL(6)	A–D	O NO	50 40	55 35	

(13) *Inspector's ringback circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
CB	352098	.008	RD(NO)	1	SW(5, 23)	A–C, B–D	O	15	16	
							NO	13	12	
RD	358818	.004	SW(NO)	5	CB(3)	A–D	O	22	24	
							H	10	11	
							R	8	7	
SW	358828	Note 9	RD(NO)	5	RT(8)	A–D	O	40	44	
							H	10	11	
							R	8	7	
RV	352099	.004	----------	5	SW(3)	A–C	O	11	12	
							NO	8	7	
RT	352100	.004	----------	5	RT(B)	B–D	O	27	29	
							NO	23	20	
							O	13	13.5	X contact only.
							NO	11	10	X contact only.

(14) *Connector intercept circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
SL	359501	.004	----------	6	SL(B)	A–B	O	33	36	Type C relay.
							NO	27	24	
SN	359501	.004	SN (21, 22)	5	SL(1)	C–D	O	11	12	Type C relay.
							NO	7	6	***Caution:*** **Battery on SN(22).**

(15) *Shelf supervisory circuits.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
RA	352067	.004	----------	6	RA(C)	A–C	O	81	88	***Caution:*** **Releasing switches will interfere with current flow tests.**
							NO	68	62	
RA1	352067	.004	----------	6	RA1(C)	A–C	O	81	88	***Caution:*** **Releasing switches will interfere with current flow tests.**
							NO	68	62	
RA2	352067	.004	----------	6	RA2(C)	A–C	O	81	88	***Caution:*** **Releasing switches will interfere with current flow tests.**
							NO	68	62	
ATB	352069	.004	ATB(1, 2)	5	ATB(A)	A–C	O	6	7	Disconnect wire from terminal A before making current flow tests.
							NO	4.5	4	
FAA	352014	.004	FAA (1, 2) (3, 4)	6	FAA(C) (1, 2) (3, 4)	A–C	O	9.5	10.5	
							NO	7.5	6.5	
FAB	352014	.004	FAB (1, 2) (3, 4)	6	FAB(C)	A–C	O	9.5	10.5	
							NO	7.5	6.5	
RA	352014	.004	RA(1, 2)	6	RA(C)	A–C	O	37	40	
							NO	26	24	
FA	352070	.004	----------	6	FA(A)	A–C	O	6.5	7	
							NO	5	4.5	
A	352073	.004	----------	5	A(A)	A–C	O	73	80	Terminal (C) must be connected to battery.
							NO	61	55	

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
B	352073	.004	----------	5	B(A)	A–C	O	73	80	Terminal (C) must be connected to battery.
							NO	61	55	
C	352073	.004	----------	5	C(A)	A–C	O	73	80	Terminal (C) must be connected to battery.
							NO	61	55	
D	352073	.004	----------	5	D(A)	A–C	O	73	80	Terminal (C) must be connected to battery.
							NO	61	55	
FA	352074	.004	----------	6	FA(C)	A–C	O	63	69	
							NO	48	43	
EFA	352074	.004	----------	6	EFA(C)	A–C	O	63	69	
							NO	48	43	
C	352076	.004	----------	5	B(2)	B–D	O	17	18.5	
							NO	14	12.5	
A	359503	.004	B(NO)	5	C(5)	C–D	O	15.5	17	Type C relay.
							NO	13	11.5	
B	359503	.0015	----------	5	B(A)	A–B	O	13.5	14	Type C relay.
							NO	11	10	
D	359504	.004	----------	5	F(5)	C–D	O	13.5	15	Type C relay.
							NO	10	9	
E	359504	.004	----------	5	F(A)	A–B	O	15	16.5	Type C relay.
							NO	9	8	
F	352076	.004	----------	5	E(2)	B–D	O	17	18.5	
							NO	14	12.5	
SR	352014	.004	SR(1, 2)	5	SR(A)	A–C	O	9.5	10.5	
							NO	7.5	6.5	
BF	353028	.004	BF(1, 2)	5	BF(A)	A–C	O	6.3	7	
							NO	4.9	4.2	

b. Attendant's Switchboard.

(1) *Convertible line circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
SL	359527	.004	CO(NO)	6	SL(D)	C–D	O	11	12	Type C relay.
							NO	7	6	

CO	359527	.004	----------	5	SL(22)	A–B	O	20	22	Type C relay.
							NO	16.5	15	***Caution:*** **Battery on CO(4).**
LR	352445	.004	LR(1, 2) (5, 6)	5	LR(1)	B–D	O	14.5	16	***Caution:*** **Battery on LR(4, 5).**
							NO	11.5	10.5	
							O	7	8	X contact only.
							NO	6	5.5	X contact only.

(2) *Fire alarm trunk circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
RV	352202	.004	RV (23, 24) FA(NO)	5	RD(22)	A–C	O	16.5	18	
							NO	12	11	
CB	352203	.004	RD(NO)	1	RV (7, 29)	A–C, B–D	O	15	16.5	
			RV(NO)				NO	12	11	
							R	6.5	6	
RV	358819	.004	FA(NO)	5	CB(5)	A–D	O	38	41	***Caution:*** **Battery on RD(2).**
							H	10	11	
							R	8	7	
SR	352036	.004	RV(NO)	7	SR(C)	A–C	O	34	37	Disconnect wire or wires from terminal C before making current flow tests.
					RT(28)	--------	NO	25	23	
AB	352203	.004	----------	1	AB (C, B)	A–C, B–D	O	15	16.5	
							NO	12	11	
							R	6.5	6	
RT	352054	.004	RT(4, 5) (27, 28)	7	RT(3) FA(5)	A–C	O	73	79	
							NO	61	55	
							O	30	31.5	X contact only.
							NO	23	21	X contact only.
FA	352205	.004	RT(3, 4) FA(1, 2)	5	FA(2)	B–D	O	9	10	
							NO	7	6	
OC	352208	.004	CB(NO)	5	OC(2)	A–C	O	19	21	
							NO	16	14	
							O	13	13.5	X contact only.
							NO	11.6	11.2	X contact only.

(3) *Cord circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
RB	352166	.004	----------	5	RLS(5)	B–D	O	20.5	23	
							NO	15.7	14.5	
							R	5.3	4.8	
RHS	352150	.004	----------	5	RHS(A)	A–C	O	12.5	14	
							NO	9.5	9	
RLS	352151	.006	----------	6	RLS(3)	B–D	O	47	51	
							NO	40	38	
OC	352149	Note 9	OC (21, 22)	5	OC(2)	A–C	O	41	45	
							NO	20	18	
							O	13	13.5	X contact only.
							NO	11.6	11.2	X contact only.
FLS	352151	.006	----------	6	FLS(3)	B–D	O	47	51	
							NO	40	38	
FHS	352150	.004	----------	5	FHS(A)	A–C	O	12.5	14	
							NO	9.5	9	
FB	352166	.004	----------	5	FLS(5)	B–D	O	20.5	23	
							NO	15.7	14.5	
							R	5.3	4.8	

(4) *Position and dial circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
MR	352171	.004	MR(6, 7)	7	MR (A, C)	A–C	O	16.5	18	Disconnect wires from terminals (A, C) before making current flow tests.
							NO	13.5	12	
MR1	352155	.004	----------	5	MR(2)	A–C	O	15	16.5	
							NO	12	11	
FON	358829	.004	----------	5	FON1(4)	A–C	O	44	48	
							NO	36	33	
RON	358829	.004	----------	5	RON1(4)	A–C	O	44	48	
							NO	36	33	
FON1	352175	.004	FON(NO)	5	FON(1)	A–C	O	13	14.5	
							NO	10.5	9.5	
							O	7	7.5	X contact only.
							NO	6	5.5	X contact only.

RON1	352175	.004	RON(NO)	5	RON(1)	A–C	O	13	14.5	
							NO	10.5	9.5	
							O	7	7.5	X contact only.
							NO	6	5.5	X contact only.

(5) *Operator and position switching circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
OB	352390	.004	----------	5	OB(A)	A–C	O	14	15	Disconnect wire or wires from terminal (A) before making current flow tests.
							NO	12	11	
MO	352136	.004	----------	5	MO(A)	A–C	O	23	25	
							NO	17	15	
OT	359507	.004	----------	5	OT(C)	C–D	O	19	21	Type C relay.
							NO	14.5	13	
TR	359507	.004	----------	5	TR(A)	A–B	O	21	23	Type C relay.
							NO	11.5	10.5	
SW1	352049	.004	----------	5	SW1(A)	A–C	O	12	13	
							NO	10	9	
SW	352050	.004	SW1(NO)	5	SW(A)	A–C	O	12	13	
							NO	10	9	

(6) *Peg count circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
PC	352053	.004	PC(3, 4)	5	PC(4)	B–D	O	16.5	18	
							NO	13	11.5	
							O	10.5	11.5	X contact only.
							NO	8.5	7.5	X contact only.

(7) *Fuse alarm circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
FA	352029	.004	FA(1, 2)	6	FA(C)	A–C	O NO	55 45	60 40	

(8) *Line pilot, supervisory pilot, and night alarm circuits.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
LP	803103	Fixed	----------	----------	LP(1, 4)	1–4	O R	----------	27 2	Line pilot circuit.
SP	803103	Fixed	----------	----------	SP(1, 4)	1–4	O R	----------	27 2	Supervisory pilot circuit.
NA	803103	Fixed	----------	----------	NA(1, 4)	1–4	O R	----------	27 2	Night alarm circuit.

c. *Information Desk.*

(1) *Lamp transfer circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
SW	352277	.004	----------	5	SW(A)	A–C	O NO	16 13	17 12	

(2) *Operator's circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
OB	352129	.004	OB(1, 2) (3, 4)	7	OB(B, C)	A–C, B–D	O	18	20	Disconnect wires from terminals (C, B) before making current flow tests.

MO	359511	.004	----------	5	MO(A)	A–B	R O NO	7 17 13.5	6 18.5 12	Type C relay.
OT	359511	.004	----------	5	OT(C)	C–D	O NO	16 12.5	18 11	Type C relay. Disconnect wires from terminal (C) before making current flow tests.

d. Test Desk and Testing Unit.

(1) *Two-way-to-line trunk circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
SL	352172	.004	SL(2, 3)	5	SL(A)	A–C	O NO	9 6.5	10 6	
TB	352273	.004	TA(5, 6)	5	TA(5)	A–C	O NO	12.5 11.5	13.5 10.5	
TA	352274	.004	TB(O) TA(5, 6)	5	TA(6)	A–C	O NO	7.5 6	8.5 5.5	
LP	352275	.004	----------	7	LP(A, C)	A–C	O NO	10.5 8	11.5 7	Disconnect wire or wires from terminals (A, C) before making current flow tests. ***Caution:*** **Battery on LP(2).**

(2) *Selector level trunk circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
RD	358843	.004	RS(1, 2)	5	CH(5)	A–D	O H R	41 10 8	45 11 7	***Caution:*** **Battery on RD(24).**
CB	352000	.006	RD(NO)	1	GC (25, 28)	A–C, B–D	O NO	18.5 15.5	19.5 14.5	Limited travel relay.
GS	352278	Note 9	CB(NO)	5	GS(A)	A–C	O R	116 50	123 44	
RS	352790	.004	----------	5	RS(A)	A–C	O NO	22 18	24 16	

(3) *Test selector trunk circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
HG	352243	.004	SA1 (21, 22)	5	HG(A)	A–C	O	18	20	***Caution:*** **Battery on HG(8).**
							NO	15	13.5	
RG	352244	.004	BY(NO)	5	HG(2)	A–C	O	6	6.5	
							NO	4.5	4	
SA1	358841	.004	SB(NO)	5	SA(4)	A–D	O	37	40	
							NO	30	27	
SA	352245	.004	----------	7	SA(A, C)	A–C	O	24	26	Disconnect wires from terminals (A, C) before making current flow tests.
							NO	20	18	
							R	9.5	8.5	
SB	352246	.004	----------	5	SA1(3)	A–C	O	14.5	16	
							NO	9.5	8.5	
BY	352130	.004	----------	7	RG(2, 6)	A–C	O	15.5	17	***Caution:*** **Battery on BY(2).**
							NO	12.5	11	

(4) *Main testing circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
AC	352299	.004	----------	7	AC(A, C)	A–C	O	37	40	Disconnect wires from terminals (A, C) before making current flow tests.
							NO	31	28	
MT	352092	.004	----------	5	RR(8)	A–C	O	16	17.5	
							NO	11.5	10	
MS	352258	.004	----------	7	MS(A, C)	A–C	O	9	10	Disconnect wires from terminals (A, C) before making current flow tests.
							NO	6.5	6	
TB	352353	.004	----------	1	TB(C, B)	A–C B–D	O	16.5	18	
							NO	13.5	12	
CR	352092	.004	----------	5	CR(A)	A–C	O	16	17.5	
							NO	11.5	10	
DC	352300	.004	----------	5	DA(7)	A–C	O	16	18.5	
							NO	12.5	11.5	

DB	352302	.004	----------	5	DB(4)	A–C	O	20	22	
							NO	15	13	
DA	352303	.006	DA(NO)	5	DA(A)	A–C	O	24	27	
							NO	19	17	
NA	352305	.003	----------	7	NA1, (B, D)	B–D	O	6.5	7	Disconnect wires from terminals (B, D) before making current flow tests.
							NO	5	4.5	
NA1	352305	.003	----------	7	NA(B, D)	B–D	O	6.5	7	Disconnect wires from terminals (B, D) before making current flow tests.
							NO	5	4.5	
SP	352306	.004	----------	5	SP(A)	A–C	O	10	11	
							NO	8	7	
OP	352092	.004	----------	5	OP(A)	A–C	O	16	17.5	
							NO	11.5	10	
RV	352092	.004	----------	5	RV(A)	A–C	O	16	17.5	
							NO	11.5	10	
RS	352307	.004	----------	5	RR(2)	A–C	O	10	11	
							NO	6.5	5.5	
RR	352308	.004	MT(NO)	5	RR(A)	A–C	O	10	11	
							NO	8	7	
MN	352304	.004	----------	5	MN(A)	A–C	O	18	20	
							NO	13	12	
SA	352306	.004	----------	5	SA(A)	A–C	O	10	11	
							NO	8	7	
OA	352092	.004	----------	5	OA(A)	A–C	O	16	17.5	
							NO	11.5	10	
PS	352309	.004	----------	5	PS(A)	A–C	O	6.5	7	
							NO	5	4.5	

(5) *High voltage breakdown test circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
PU	352316	.004	C1(NO)	5	PU(23)	A–C	O	11	12	
							NO	9	8	
FL	352317	.004	----------	5	PU(22)	A–C	O	5	5.5	
							NO	4	3.5	
C1	352319	.004	----------	5	C2(3)	A–C	O	11	12	
							NO	9	8.5	
C2	352320	.004	C2(1, 2)	5	C2(1)	A–C	O	12	13	
							NO	10	9	

(6) *Pulse speed and percent make circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
CB	352814	.004	PA(NO)	1	CB(B, C)	A–C, B–D	O	18	19	Limited travel relay.
							NO	16	15	
SH	352789	Note 9	----------	5	PA(6)	A–C	O	21	23	
							NO	16	14	
PA	352844	.008	----------	5	SH(9, 23)	A–C	O	14	15	
							NO	11	10	

(7) *Sounder circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
SB	359502	.004	----------	5	SB(A)	A–C	O	7	8	
							NO	5.5	5	
SA	---------	.010	SB(NO)	---------	SA(C, B)	A–C, B–D	O	23	25	
							R	13	12	

(8) *Test selector circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
DA	359502	.004	----------	5&10	DA(C)	C–D	O	18	20	Type C relay.
							NO	13	12	
DC	359502	.004	DA (21, 22)	5&10	DC(A)	A–B	O	16	18	Type C relay.
							NO	11	10	
AP	352199	.004	----------	6	CG(1)	A–D	O	27	30	
							NO	22	20	

PR	352059	.004	----------	7	PR(B, D)	B–D	O	77	81	Disconnect wires from terminals (B–D) before making current flow tests.
							NO	60	54	
LD	352060	.009	----------	7	LD(A, C)	A–C	O	70	77	Disconnect wire or wires from terminal (C) before making current flow tests.
							R	44	39	
LR	352061	.004	----------	5	CD(4)	A–C	O	15.5	17	
							H	5	6	
LA	352066	.004	----------	5	LR(2)	A–C	O	10	11	
							NO	7.5	6.5	
CG	352068	.004	RD(NO)	6	LA(5)	A–C	O	16	18	
							NO	13	11.5	
CB	352068	.004	----------	5	LA(3)	A–C	O	16	18	
							NO	13	11.5	
RD	358803	Note 9	CG(3, 4)	5&10	CG(5)	A–D	O	41	45	
							H	10	11	
							R	8	7	
XA	358816	.004	----------	5&10	CS(6)	B–D	O	41	45	
							NO	29	26	
XB	358816	.004	----------	5&10	XB(8)	A–C	O	50	55	
							NO	35	31	
YD	352071	.0015	SW (23, 24)	5	SW(24)	A–C	O	26	29	
							NO	21	18	
BT	352072	.004	YD(7, 8)	7	YD(8) BD(27)	A–C	O	17.5	19	
							NO	12	10.5	
BD	352075	.004	----------	5	YD(7)	A–C	O	29	32	
							NO	22	20	
SA	352077	.004	SW (28, 29)	5	SW(8)	A–C	O	17	19	
							NO	13.5	12	
SW	352078	.004	BT(5, 6)	7	SW(A) BD(25)	A–C	O	45	51	
							NO	34	30	
TS	352439	.004	SA(NO)	5	YD(5)	A–C	O	20	22	
							NO	15	13.5	
CD	352080	.004	LA (21, 22) CF(5, 6)	5	LA(22)	A–C	O	17	18.5	
							NO	14	12	
CF	352081	.004	----------	5	CF(2)	B–D	O	14	15	
							NO	11.5	10.5	
							O	7	8	X contact only.
							NO	5.5	5	X contact only.
CS	352082	.004	----------	5	CS(2)	A–C	O	17.5	19	
							NO	14.5	12	
							O	7	8	X contact only.
							NO	6	5.5	X contact only.
LS	352420	.012	TS (23, 24)	7	LS(1) TS(24)	A–C	O	100	105	
							NO	90	85	

(9) *Test connector circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
CB	352057	.006	RD(NO)	5	CB(A)	A–C	O	14	15.5	Operate busy key before making current flow tests.
							NO	11	10	
RD	358810	.004	----------	5&10	CB(5)	A–D	O	34	37	
							H	10	11	
							R	8	7	
XD	352058	.004	----------	5&10	E(19)	A–C	O	25	27	
							NO	21	19	

(10) *Testing unit circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
MS	352258	.004	----------	7	MS(A, B)	A–C	O	9	10	Disconnect wires from terminals (A, C) before making current flow tests.
							NO	6.5	6	
BZ	352259	.009	----------	5	BZ(8)	B–D	O	80	86	
							NO	68	62	
HL	352260	.004	BZ(NO)	5	HL(2)	A–C	O	11.5	12.5	
							NO	9.5	8.5	
							O	4.5	5	X contact only.
CB	352262	.006	----------	1	CB(B, C)	A–C, B–D	O	20	22	
							NO	16.5	15	
DA	352263	.004	DB(NO)	5	DA(A)	A–C	O	15.5	17	
							NO	12.5	11	
DB	352264	.004	----------	5	DA(3)	A–C	O	37	41	
							NO	30	27	
BY	352265	.004	----------	5	BY(B)	B–D	O	9.5	10.5	
							NO	7	6	
SA	352266	.006	DA(1)(2) DB(1)(2)	7	SA(A, C)	A–C	O	24	26	
							NO	20	18	
							R	9.5	8.5	
SB	352267	.004	SB(27, 29)	5	SB(29)	A–C	O	13	14	
							NO	10	9	

e. Testing Equipment.

(1) *Pulse speed and per cent make test set circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
PA	359550	.004	----------	5	PA(C)	C–D	O	17	19	Type C relay. Disconnect wire or wires from terminals PA(C) before making current flow tests.
							NO	14	13	
PB	359550	.0015	----------	5	PA(21)	A–B	O	42	46	Type C relay.
							NO	24	20	
CB	352430	.009	----------	5	CB(A)	A–C	O	33	36	Limited travel relay.
							H	20	22	Disconnect wire or wires from terminal CB(A) before making current flow tests.
							R	18	16	
MS	352431	.004	----------	7	MS(A, C)	A–C	O	7	8	Disconnect wire or wires from terminals MS(A, C) before making current flow tests.
							NO	6	5	

(2) *Connector routine test circuit plate circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
										Operate busy key before making current flow tests.
SL1	359521	.004	PU(NO)	5	SL2 (24)	A–B	O	25	27	Type C relay.
							NO	20	18	
SL2	359521	.004	SL1(NO)	5	SL1(11)	C–D	O	46	50	Type C relay.
							NO	38	34	
AC	352195	.004	----------	7	AC(A, C)	A–C	O	17	18.5	Disconnect wires from terminals (A, C) before making current flow tests.
							NO	12	11	
AD	359522	.004	----------	5	AC(3)	A–B	O	11.5	13	Type C relay.
							NO	8	7	
PN	359522	.004	RU(NO)	5	PN(28)	C–D	O	21	23	Type C relay.
							NO	14	12.5	

PU	359523	.004	----------	5	PU(4)	A–B	O	19	21	Type C relay.
							NO	14	12.5	
RV	359523	.004	PN (25, 26)	5	PN(23)	C–D	O	22	24	Type C relay.
							NO	18.5	17	

(3) *XY Switch test set circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
PA	360095	.004	----------	5	PA(4)	B–D	O	11.5	12.5	
							NO	8.5	7.5	
PB	361663	.009	----------	5	PB(A)	A–C	O	18.5	20.5	
							NO	15.5	14	
YS	363159	.004	----------	5	YS(A)	A–C	O	20	22	Remove release lamp (red) from lamp strip.
							NO	15.5	13.5	
HAB	361610	.006	----------	7	HAB (A, C)	A–C	O	66	73	Disconnect wiring from HAB (A, C) before making current flow tests.
							NO	54	50	
XS	363159	.004	----------	5	E2	A–C	O	22	24	Disconnect XY switchplug before making current flow tests.
							NO	17	15	
HAS	361653	.007	----------	7	HSS (A, C)	A–C	O	77	84	Disconnect wiring from HAS(A, C) before making current flow tests.
							NO	63	56	
A	365121	Note 9	----------	5, 9	Term. 2	A–D	O	28	30	Remove strap between terminal 1 & 2 from terminal 2.
							NO R	24	22	
B	364196	Note 9	----------	5, 9	Term. 4	A–D	O	36	39	Remove strap between terminals 3 & 4.
							NO R	30	27	
C	361459	Note 9	----------	5, 9	Term. 6	A–D	O	34	37	Remove strap between terminals 5 & 6.
							NO R	28	25	
D	361459	Note 9	----------	5, 9	Term. 8	A–D	O	34	37	Remove strap between terminals 7 & 8.
							NO R	28	25	

(4) *Circuit plate maintenance test set circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
HS	352425	.004	----------	5	HS(A)	A–C	O	8.5	9.5	
							NO	7	6.5	
SL	352426	.006	----------	5	CB(7)	A–C	O	31	34	
							NO	26	23	
SG1	352427	.004	SG(5, 6)	5	SG(6)	A–C	O	10.5	11.5	
							NO	8	7	
SG	352428	.0015	----------	5	CB(4)	A–C	O	23	25	
							NO	20	17.5	
DR	352429	.008	----------	5	DR(26)	A–C	O	13	14	
							NO	10.5	9.5	
CB	352430	.009	SG(NO)	5	CB(A)	A–C	O	33	36	Limited travel relay.
							H	20	22	
							R	18	16	
MP	352431	.004	----------	7	MP(A, C)	A–C	O	7	8	Disconnect wires from terminals (A, C) before making current flow tests.
							NO	6	5	
DS	352432	.004	DS (25, 26) TA, (NO)	5	DS(A)	A–C	O	29	31	
							NO	24	22	
PL	352433	.004	----------	7	PL(A, C)	A–C	O	10	11	Disconnect wires from terminal (A, C) before making current flow test.
							NO	8	7	
DD	352434	.004	----------	5	DD(A)	A–C	O	14	16	
							NO	11.5	10.5	
HA	352436	.004	HA(3, 4)	5	HA(A)	A–C	O	24	26	
							NO	18	16	
TC	352435	.005	----------	5	TB(22)	A–D	O	35	38	
							NO	30	27	
TB	358809	.005	TB (21, 22)	5	TA(3)	A–D	O	38	42	
							NO	33	30	
TA	358809	.005	TB(NO)	5	DS(4)	A–D	O	38	42	
							NO	33	30	
TD	352247	.004	----------	5	DR(23)	A–C	O	8	9	
							NO	6.5	6	
PA	359525	.004	DS(27, 28) (25, 26)	5	RA(A)	A–B	O	24	26	Type C relay.
							NO	17	15	
PB	359525	.004	----------	5	PA(1)	C–D	O	14	16	Type C relay.
							NO	9	8	

f. Power, Ringing, and Supervisory Equipment.

(1) *Power and common supervisory circuit (50-line PX and 60-line PBX).*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
E	352088	.004	D (21, 23)	5	D(23)	A–C	O	21	23	
							NO	17	15	
F	352089	.004	G(5, 6) F(1, 2)	5	G(5)	A–C	O	11	12	
							NO	9	8	
G	352090	.004	G(6, 7)	5	F(3)	B–D	O	9.5	10.5	
							NO	7	6	
H1	352091	.004	----------	5	F(8)	A–C	O	12	13	
							NO	9.5	8.5	
H2	352092	.004	----------	5	G(4)	A–C	O	16	17.5	
							NO	11.5	10	
H3	352093	.004	H2 (1, 2)	5	H2(2)	A–C	O	14.5	16	
							NO	12	10.5	
LV	352094	.012	AR(O)	5	LV(A)	A–C	O	115	125	Disconnect wires from terminal (A) before making current flow tests.
							NO	95	85	
							H	70	75	
							R	63	56	
AR	352095	.012	FST(1, 2) AR(1, 2) (4, 5)	5	FST(1)	A–C	O	11.5	13	
							NO	8	7.5	
DA	359505	.004	AR(O) ALM(O)	5	ALM(4)	C–D	O	13.5	15	Type C relay.
							NO	10	9	
SA	359505	.004	AR(O) FST(O)	5	FST(4)	A–B	O	10.5	11.5	Type C relay.
							NO	7.5	6.5	
ALM	352096	.004	AR(O) ALM (3, 5)	5	ALM(B)	B–D	O	19	21	
							NO	14	12.5	
FST	362096	.004	AR(O) FST (3, 5)	5	FST(B)	B–D	O	19	21	
							NO	14	12.5	
FA	352074	.004	----------	6	FA(C)	A–C	O	63	69	Disconnect wires from terminal (C) before making current flow tests.
							NO	48	43	
ST	359506	.004	----------	5	ST(C)	C–D	O	15.5	17	Type C relay.
							NO	13	11.5	
ST1	359506	.004	----------	5	ST1(A)	A–B	O	13.5	15	Type C relay.
							NO	10	9	
PA	358817	.005	----------	5	PA(A)	A–C	O	18.5	20	Disconnect wires from terminal (A) before making current flow tests.
							NO	16.5	14	
PB	358817	.005	PA (21, 22)	5	PB(A)	A–C	O	18.5	20	Disconnect wires from terminal (A) before making current flow tests.
							NO	16.5	14	

A	352083	.004	B(3, 4) A(1, 2)	5	B(3)	A–C	O NO	11 9	12 8	
B	352085	.004	B(4, 5)	5	A(3)	B–D	O NO	12.5 10.5	13.5 9.5	
C	352086	.004	E (23, 25)	5	E(25)	A–C	O NO	19 15	21 13	
D	352087	.006	E(6, 7)	5	D(A)	A–C	O NO	20 16.5	22 15	

(2) *Common supervisory circuit (200- and 400-line central offices).*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
F	352074	.004	E(NO)	6	F(C)	A–C	O NO	63 48	69 43	
EF	352074	.004	E(NO)	6	EF(C)	A–C	O NO	63 48	69 43	
CHG	352140	.004	E(NO)	5	CHG(A)	A–C	O NO	4.5 3.5	5 3	
SA	352196	.004	E(NO)	5	SA(A)	A–C	O NO	7 5.5	8 5	
SB	352197	.004	E(NO)	5	SB(A)	A–C	O NO	5 3.5	5.5 3	
SC	352076	.004	SC(5, 7); E(NO)	5	SB(2)	B–D	O NO	17 14	18.5 12.5	
HC	352074	.004	E(NO)	5	HC(A)	A–C	O NO	63 48	69 43	
LV	352094	.012	VA(O); VB(NO)	5	LV(A)	A–C	O NO	115 95	125 85	
VA	352198	.004	VB(O); E(NO)	5	VB(3)	A–C	O NO	10 7.5	11 7	
VB	352199	.004	E(NO)	5	LV(1)	A–D	O NO	26 22	28 20	
DA	352200	.004	DB(NO)	5	DC(5)	A–C	O NO	6 4.5	6.5 4	
DB	352201	.004	DC(NO)	5	DB(2)	B–D	O NO	7 5.5	8 5	
DC	352076	.004	----------	5	DB(4)	B–D	O NO	17 14	18.5 12.5	
ST1	352204	.004	----------	5	STI(A)	A–C	O NO	8 6.5	9 6	

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
ST	352205	.004	ST(3, 4)	5	ST(A)	A–C	O	9	10	
							NO	7	6	
SF	352196	.004	----------	5	SF(A)	A–C	O	7	8	
							NO	5.5	5	
E	352206	.004	E(3, 4)	5	VB(5)	A–D	O	28	30	
							NO	24	22	
CO	352207	.004	----------	5	CO(5)	A–C	O	11	12	
							NO	9	8	

(3) *Common supervisory circuit (600–5,000-line central offices).*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
FL	352074	.004	FL(3, 4)	6	FL(C)	A–C	O	63	69	Disconnect wire or wires from FL(C) before making current flow tests.
							NO	48	43	
EF	352219	.004	FA(NO)	5	EF(A)	A–C	O	9	10	
							NO	6.5	6	
FA	352205	.004	----------	5	EF(2)	A–C	O	9	10	
							NO	7	6	
FB	352221	.004	----------	5	FB(6)	B–D	O	11.5	12.5	
							NO	9	8	
EA	352185	.004	----------	5	EA(A)	A–C	O	9	10	
							NO	7	6	
EB	352222	.004	----------	5	EB(5)	B–D	O	11.5	12.5	
							NO	9	8	
ES	352174	.004	----------	5	ES(A)	A–C	O	11	12	
							NO	9	8	
TA	352205	.004	TC(NO); TB(4, 5)	5	TB(4)	A–C	O	9	10	
							NO	7	6	
TB	352223	.004	TB(5, 6)	6	TA(6)	A–C	O	13	14	
							NO	11	10	
TC	352224	.004	----------	5	TB(7)	A–C	O	8	9	
							NO	6	5	
TD	352109	.004	----------	5	TC(2)	A–C	O	10	10.5	
							NO	7.5	7	
PA	352089	.004	PB(3, 4)	7	PA(A, C)	A–C	O	11	12	Disconnect wire or wires from terminal A, C before making current flow tests.
							NO	9	8	

PB	352221	.004	---------- HC(1, 2)	5	PB(6)	B–D	O NO	11.5 9	12.5 8	
HC	352581	.004	(3, 4)	5	HC(A)	A–C	O NO	300 250	325 225	
ST1	352204	.004	ST(1, 2)	5	ST1(2)	B–D	O NO	8.5 7	9.5 6.5	
ST	352205	.004	ST(1, 2)	5	ST(2)	B–D	O NO	9.5 7	10.5 6	

(4) *Voltage control circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
A	352114	.004	B(3, 4)	5	B(4)	B–D	O NO	9 6.5	10 6	
B	352116	.004	D(1,2) A(1, 2)	5	D(2)	A–C	O NO	11 9	12 8	
C	352117	.004	D(NO)	5	B(23)	A–D	O NO	21 17	23 15	
D	358825	.004	----------	5	C(2)	A–D	O NO	39 33	43 30	
E	352122	.004	A(1,2) H(2, 3) E(21, 22) (23, 24)	5	E(2)	B–D	O NO	10.5 9	11.5 8	
H	352121	.004	H(1, 2)	6	H(C)	A–C	O	18.5	20	Disconnect wire or wires from terminal (C) before making current flow tests.
L	352121	.004	L(1, 2)	6	L(C)	A–C	O	18.5	20	Disconnect wire or wires from terminal (C) before making current flow tests.

(5) *Ac interrupter control circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
E	352209	.004	----------	5	E(A)	A–C	O NO	6 4.5	6.5 4	Disconnect wire or wires from terminal (A) before making current flow tests.
A	352210	.004	C(NO) D(1, 2) A(26, 28)	5	A(26)	A–C	O NO	12 9	13 8	

B	352211	.004	C(NO) A(3, 4)	5	A(4)	A–D	O H R	17.5 6.5 4.5	19 7 4	
C	352211	.004	A(6, 7)	5	A(7)	A–D	O H R	17.5 6.5 3	19 7 2.5	
D	352212	.004	A(NO)	5	C(2)	A–D	O NO	33 28	37 25	
K	352213	.004	----------	5	K(A)	A–C	O NO	19 14	21 12.5	Disconnect wire or wires from terminal (A) before making current flow tests.
J	352213	.004	----------	5	J(A)	A–C	O NO	19 14	21 12.5	Disconnect wire or wires from terminal (A) before making current flow tests.
H	352213	.004	----------	5	H(A)	A–C	O NO	19 14	21 12.5	Disconnect wire or wires from terminal (A) before making current flow tests.
G	352213	.004	----------	5	G(A)	A–C	O NO	19 14	21 12.5	Disconnect wire or wires from terminal (A) before making current flow tests.
F	352214	.004	----------	5	A(1)	A–C	O NO	16.5 12	18 11	

(6) *Dc interrupter control circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
D	352212	.004	----------	5	C(2)	A–D	O NO	33 28	47 25	
C	352211	.004	A(3, 4)	5	A(4)	A–D	O H R	17.5 6.5 4.5	19 7 4	
B	352211	.004	D(NO)	5	A(4)	A–D	O H R	17.5 6.5 4.5	19 7 4	
A	352210	.004	C(NO) A(26, 28) D(1, 2)	5	A(26)	A–C	O NO	12 9	13 8	
E	352209	.004	----------	5	E(A)	A–C	O	6	6.5	Disconnect wire or wires from terminal (A) before making current flow tests.

(7) *Tone generator circuit (200–5,000-line central offices).*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
A	352110	.004	----------	5	A(A)	A–C	O	10	11	
							NO	7.7	7	

(8) *Ringing control circuit (200- and 400-line central offices).*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
F	352139	.004	----------	6	F(C)	A–C	O	6	6.5	
							NO	4.5	4	
E	352236	.004	(D1, 2)	5	D(2)	A–C	O	6	6.5	
			H(NO)				NO	4.5	4	
H	352204	.004	----------	5	E(4)	A–C	O	8	9	Operate alarm transfer switch.
							NO	6.5	6	
K	352237	.004	K(3, 5)	5	J(3)	A–C	O	88	9	
			J(NO)				NO	5	4.5	
J	352173	.004	K(O)	5	J(A)	A–D	O	26	28	
			K(3, 5)				NO	21	19	
G	352235	.004	----------	7	G(A, C)	A–C	O	4	4.5	Disconnect wires from terminals (A, C)
							NO	3	2.5	before making current flow tests.
D	352114	.004	----------	6	C(1)	A–C	O	9	10	
							NO	6.5	6	
C	352238	.004	C(1, 2)	5	C(2)	B–D	O	14.5	15.5	
			D(1, 2)				NO	12.5	11.5	
A1	352239	.004	B1(23, 24)	5	B1(23)	A–C	O	12.5	13.5	
							NO	10.5	9.5	
B1	352240	.004	B1(1, 2)	7	B1(4, 24)	A–C	O	15.5	17	
			(23, 24)							
			C							
			(21, 22)							
							NO	12	11	
							O	7.5	8.5	X contact only.
							NO	6	5.5	X contact only.
A2	352239	.004	B1(23, 24)	5	B1(23)	A–C	O	12.5	13.5	
							NO	10.5	9.5	

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
B2	352240	.004	B1(1, 2) (23, 24) C (21, 22)	7	B1(4, 24)	A–C	O	15.5	17	
							NO	12	11	
							O	7.5	8.5	X contact only.
							NO	6	5.5	X contact only.

(9) *Battery discharge and distribution circuit.*

Relay	Manufacturer's part No.	Resid (inch)	Block or insulate	Test with (see note)	Test set point	Test wdg	Test for	Readj ma	Test ma	Remarks
A	352108	.004	A(1, 2)	7	A(A, C)	A–C	O	3.5	4	Disconnect wires from terminal (A, C) before making current flow test.
							NO	2.5	2	
B	352126	.004	A(23) B(1, 2) (5, 6)	5	A(1)	B–D	O	22	24	
							NO	18	16	

CHAPTER 7

REMOVAL AND REPLACEMENT OF SWITCHING CIRCUIT PLATE COMPONENTS

192. General

When parts are damaged or excessively worn, new parts should always be used as replacements to restore the equipment to service. When new parts are not available, old parts may be repaired to keep the equipment operating until new parts can be obtained. When making repairs, observe the general rules given in *a* and *b* below.

a. Identification of Leads. Before removing parts, unsolder and tag each wire. After the part has been replaced, make sure that each wire is returned to its proper terminal.

b. Electrical Connections. When replacing wires, cut the new leads to the lengths required for proper dressing and satisfactory connections. Do not use more solder than is necessary for good connections, and be careful not to drop solder on other parts. Hold the soldering iron on the terminal only long enough to obtain a good connection. Do not char insulation by applying excessive heat.

193. Repair Procedures

a. Replacing Fuses.
(1) Loosen the two screws that secure the fuse to the fuse panel.
(2) Lift the right end of the fuse and slide the fuse to the left; remove the fuse.
(3) Place a new fuse in the proper mounting position on the fuse panel and tighten the two mounting screws until the fuse is securely mounted.

b. Replacing Resistors.
(1) Identify the resistor to be replaced.
(2) Tag and unsolder all leads connected to the resistor.
(3) Remove the mounting nut and lockwasher.
(4) Remove the resistor and the insulating washer from the mounting screw.
(5) Place a new resistor on the mounting screw and replace the insulating washer.
(6) Place the new resistor in the proper mounting position.
(7) Replace the lockwasher and mounting nut. Tighten the mounting nut until the resistor is securely in place.
(8) Resolder the leads and remove the tags.

c. Replacing Capacitors.
(1) Identify the capacitor to be replaced.
(2) Tag and unsolder all leads connected to the capacitor.
(3) Remove the two nuts, screws, and lockwashers that secure the capacitor.
(4) Place the new capacitor in the proper mounting position.
(5) Replace the two capacitor mounting screws, nuts, and lockwashers; tighten the mounting nuts until the capacitor is securely in place.
(6) Resolder the leads and remove the tags.

d. Replacing Transformers.
(1) Tag and unsolder all leads from the transformer to be replaced.
(2) Remove the two screws and lockwashers and remove the transformer.
(3) Place a new transformer in the proper mounting position and replace the two lockwashers and mounting screws. Tighten the mounting screws until the transformer is securely in place.
(4) Resolder each lead and remove the tags.

e. Replacing Relays.
(1) Identify the relay to be replaced.
(2) Tag and unsolder all leads connected to the relay.
(3) Remove the mounting screws that secure the relay.

(4) Place a new relay in the proper mounting position and secure it in place with the mounting screws.
(5) Resolder the leads to the relay and remove the tags.
(6) Dress the wires to prevent shorted terminals.

f. Replacing Terminal Boards.

(1) Remove the two screws that secure the terminal board to the circuit plate.
(2) Tag and unsolder all leads connected to the terminal board to be replaced.
(3) Place a new terminal board in the proper mounting position.
(4) Replace the two screws that secure the terminal board and tighten the mounting screws.
(5) Resolder the leads and remove the tags.

g. Replacing Make Busy and Test Unit Assembly.

(1) Tag and unsolder all leads connected to the make busy and test unit to be replaced.
(2) Unscrew and remove the assembly fastening nuts.
(3) Remove the assembly from the front of the circuit plate.
(4) Place a new make busy and test unit into the proper positioning hole.
(5) Place and tighten the assembly fastening nuts on the base block assembly.
(6) Resolder the leads and remove the tags.
(7) Dress the leads to prevent shorted terminals.

h. Replacing Lamps.

(1) Remove the lamp cap; use the lamp cap extractor.
(2) Insert a lamp extractor tool into the lamp socket. Press down on the tool, then pull it straight out.
(3) Remove the lamp from the lamp extractor.
(4) Place a new lamp into the lamp extractor tool, then insert the tool into the lamp socket.
(5) Remove the lamp extractor tool.
(6) Replace the lamp cap.

CHAPTER 8
CLEANING AND LUBRICATION

Section I. CLEANING

194. General

Remove excess oil, foreign matter, dirt, rust, or corrosion from the relays, dials, switches, plugs, cords and jacks. If a vacuum cleaner is available, remove as much dust from the frames and assemblies as possible. The vacuum cleaner may be further used to collect dust and dirt as it is removed from the various equipments. The tools and cleaning supplies required to perform the cleaning routines are listed below.

Signal Corps stock No.	Description
	No. 0000 sandpaper.
6Z2056	Cotton cloth.
	No. 6 camel's-hair brush.
	Floor cleaning compound.
	Cleaning compound (FSN 7930–395–9542).
	Dry compressed air at a maximum pressure of 60 psi.
6N6890	Cotton sleeving.
6R41065C	Hand Contact Burnisher TL–577/U.
6Z73060	Orange stick.
	Bicarbonate of soda.
	Nonmetallic bristle brush.
6M213	Cord plug polish.
	Bank cleaning brush.
	Rubber gloves.
	Safety goggles.

Note. If the bank cleaning brush is not available, obtain a plastic tooth brush and insert the bristle end in hot water. After the plastic has become pliable, bend it in a U-shape to fit the bank contacts of the rotary switch.

195. Cleaning of Equipment and Switch Room

Clean the equipment and the switch room during periods of light traffic, at regular intervals, and in accordance with the instructions listed in the table below. Remove loose dust and dirt from exposed surfaces with a camel's-hair brush and a clean cloth. Remove loose dust and dirt from difficult or inaccessible areas with dry compressed air. Use a clean cloth moistened with Cleaning Compound to remove gummy or sticky deposits.

Warning: **Prolonged breathing of Cleaning Compound is dangerous. Make sure that adequate ventilation is provided. Cleaning Compound is flammable, do not use near a flame.**

Item	Procedure
Rotary switch	Remove any corrosion or rust with No. 000 sandpaper.
	Use the bank cleaning brush to remove gummy or sticky deposits from between the bank levels.
	Clean the inside of the switch cover before replacing it on the rotary switch.
	Apply compressed dry air between the magnet and armature to remove any magnetic substance.
Minor switch	Apply the bank cleaning brush to contact levels to remove any gummy or sticky deposit.
	Clean between armature and magnet of the relays with compressed air.
	Clean inside cover of switch before replacing it.
Type A and C relays	Use compressed air to remove dust from between spring contacts.
	Apply compressed air to the opening between magnet and armature.
	Use the camel's-hair brush and compressed air to remove dirt from relay armature bearings.

Item	Procedure
	Wipe out the relay cover before replacing on the relay.
	Clean the relay contacts with the burnisher.
Telephone dial	Insert a clean cloth between the finger plate and the number plate and remove loose dust.
	To remove embedded dirt on the number plate, moisten the cloth with cleaning compound.
	If extremely dirty, remove the finger plate and number plate to expose the power shaft bearing. Clean with a cloth moistened with cleaning compound.
Turn switch	Wipe exposed portions with a clean cloth and the camel's-hair brush.
	Apply dry compressed air between the spring contacts.
	Clean the contacts with the hand contact burnisher.
Push switch	Wipe the plunger with a cloth moistened with cleaning compound.
	Clean the contacts with the hand contact burnisher.
Lever switch	Clean the contacts with the hand contact burnisher.
	Remove gummy or sticky deposits with a cloth moistened with cleaning compound. Be careful not to allow the Cleaning Compound to contact the switch roller.
Peg count meter	Moisten the brush with Cleaning Compound to remove any gummy or sticky deposits.
	Brush between the number wheels.
	Clean the inside of the cover before replacing it on the unit.
Telephone jacks	Insert a clean plug into the jack and rotate it vigorously.
	For a corroded or extremely dirty jack, wrap a clean cloth spirally about an orange stick.
	Insert the cloth and stick into the jack sleeve and polish it until clean.
	Do not attempt to clean the contacts while the jack is in the circuit.
Telephone cords	Clean all soiled cords by wiping or rubbing them with a cloth moistened with cleaning compound, especially where the cord enters the plug.
	Clean corrosion from metal parts with No. 0000 sandpaper.
Telephone plug	Select a piece of cotton sleeving about 3 feet long and $\frac{1}{32}$ inch wide. Fasten one end securely.
	Apply a metal paste part way down the cloth.
	Take a turn of the sleeving around the telephone plug, and move it briskly over the metal paste.
	Polish with a clean cloth and remove all the paste from the plug.
Switch room	Keep linoleum floors lightly waxed.
	Mop clean at regular intervals with a mop slightly dampened with water.
	Uncovered floors should be sprinkled with floor cleaning compound and swept up with a pushbroom.
	Caution: **Do not use waxes and floor cleaning compounds containing turpentine or other volatile substances in such amounts as to generate fumes. These fumes tend to deposit a slight film on relay and switch contacts which may cause them to become inoperative.**
Switchboard	Remove dust, dirt, grease, and moisture from the exterior of the switchboard with a clean cloth and camel's-hair brush slightly dampened with cleaning compound.
	Remove dust from the interior of the switchboard with the soft brush and vacuum cleaner. Hold the vacuum cleaner nozzle as close to the surface being cleaned as possible.
Test equipment	Clean all dust, dirt, and grease from the test equipment panels, with a cloth and the camel's-hair brush dampened with cleaning compound.
	Remove corrosion from the metal parts with a clean cloth moistened with cleaning compound.
Distributing frames and terminal boards.	Clean the distributing frames and terminal boards with a bristle brush or vacuum cleaner suction tool.
	Tap the terminal boards lightly while using the vacuum cleaner so that particles of dirt and solder are dislodged for easier removal.
Batteries	Clean the top of the battery with a nonmetallic bristle brush.
	Clean the battery terminals with a cloth dampened with a dilute solution of bicarbonate of soda. Use bicarbonate of soda to neutralize any spilled acid.
	Warning: **Use rubber gloves and goggles when cleaning storage batteries.**

Section II. LUBRICATION

196. General

Equipment used in XY dial central offices does not require extensive and frequent lubrication. A periodic lubrication program is necessary for efficient operation and economic maintenance of the equipment.

a. Definitions. Three terms are used in expressing the amount of oil to be used in the lubrication of XY dial central office equipment.

(1) *Drop.* A drop is the amount of oil released from the end of a bare tinned copper No. 22 wire, after the wire has been dipped ½-inch into the oil, and then quickly withdrawn.

(2) *Dip.* A dip of oil is the amount retained in the bristles of a No. 6 camel's-hair brush after it has been dipped ⅜-inch into the oil, then drawn across the edge of the container to remove surplus oil. There should not be enough oil remaining in the bristles to form a drop at the end of the brush.

(3) *Small quantity.* A small quantity of oil is the amount retained on a strip of bond paper or thin fiber after being immersed in the oil, withdrawn, and the free oil wiped off.

b. Lubricants Required. The following is a table of lubricants required to oil the switches, dials, relays, and peg count meters of the XY dial central office.

Lubricant	Manufacturer's stock No.
Ratchet oil	207857
XY switch oil	204806
Dial oil (light)	209285
Dial oil (heavy)	209286

197. XY Switch (Semiannual)

All parts of the XY switch should be lubricated every 6 months, except the X and Y carriages, which should be lubricated whenever required as determined by inspection. This period of lubrication may be shortened or lengthened to meet abnormal operating conditions. Apply XY switch oil in the amounts specified to the following parts of the XY switch.

a. Refer to figure 99 for the lubrication points indicated below.

Name of part	Method
X armature hinge pin	1 dip to each end of the pin.
X retaining pawl post	1 dip down the shaft.
X drive pawl pin and spring.	1 dip to the bearing surfaces of the pin and to the spring.
X gear post and X return spring.	1 dip over surface of the post and spring.
Cog roller support	1 dip each to both sides.
Pinion assembly gears and bearings.	1 dip each to gears and bearings. Rotate cog roller by hand.
Tubular shaft	1 dip along the shaft.
Y carriage	1 dip of oil on each track.
Release magnet hinge pin	1 dip at each end of the pin.
Y stop bar	1 dip spread along the bar and coil spring.

b. Refer to figure 100 for the lubrication points indicated below.

Name of part	Method
Bearing support	1 dip on each side of bearing.
Y magnet pawl pin and spring.	1 dip at each end of pin and the spring.
X carriage assembly	1 dip of oil along the carriage path.
Right yoke	1 dip brushed in.
Y return spring assembly	1 dip brushed on spring.
XX–X rack	1 dip along rack and gear.
Y magnet hinge pin	1 dip to each end and one dip along the bearing surface.
Y retaining pawl post and spring.	1 dip only on bearing surfaces and spring.
Switching lever	1 dip only to lever and switch roller.
Spring combination assembly toggle lever.	1 dip.

198. Rotary Switch (fig. 101)

Lubricate the rotary switch every 6 months; use a No. 6 camel's-hair brush and bond paper as indicated in the chart below.

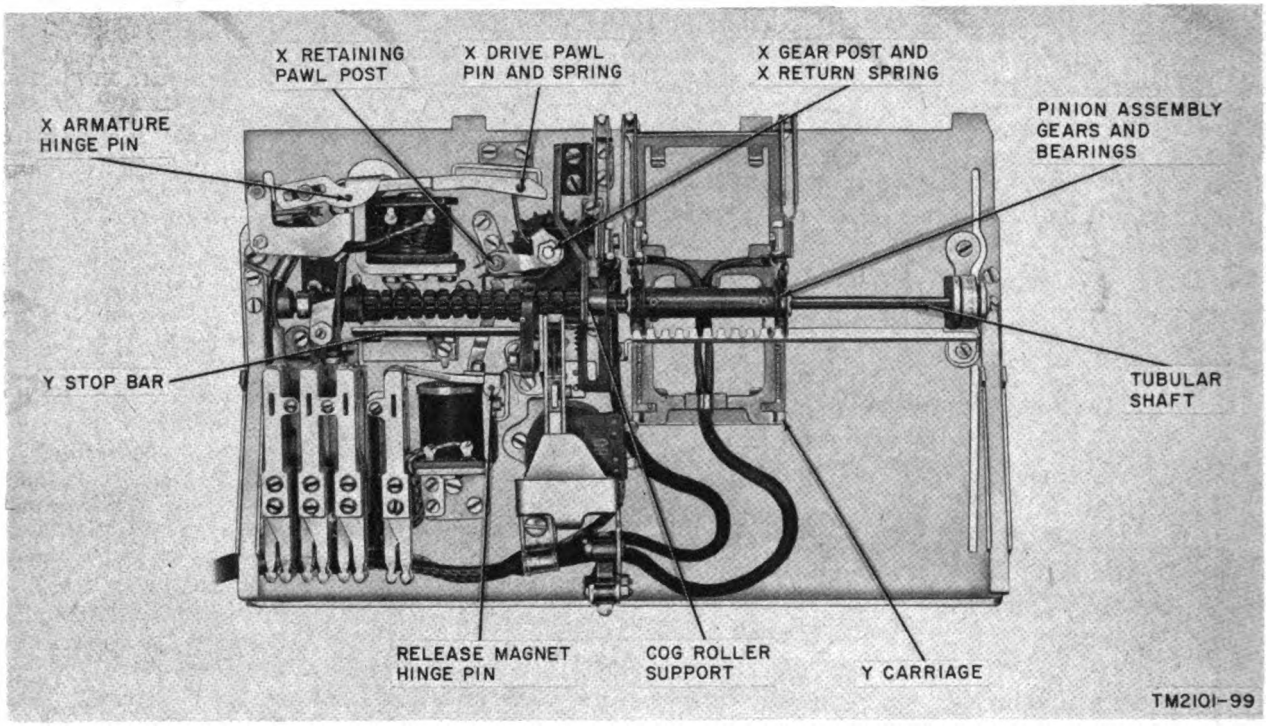


Figure 99. XY switch (normal position), lubrication points.

Name of part	Lubricant	Method
Pawl bearing	XY switch oil	1 dip to each side.
Brush springs	Dial oil (light)	1 dip to each side of the springs where the brush springs touch the wiper springs.
Armature bearing pin washers	Dial oil (light)	1 dip to each washer.
Armature bushing and driving springs.	XY switch oil	A small quantity passed between armature bushing and driving springs.
Wiper assembly bearing pin	XY switch oil	Set the wiper assembly springs in the first bank assembly contacts and carefully remove the wiper assembly bearing pin. Apply two dips to each bearing surface. Reassemble to the frame assembly.
Ratchet gear	Ratchet oil	Apply 2 dips to the ratchet teeth while rotating the wiper assembly.
Right- and left-hand wiper springs and bank contacts.	Dial oil (heavy)	Apply a small quantity between each pair of wipers and rotate the wiper assembly.

199. Minor Switch (Semiannual) (fig. 102)

Lubricate the minor switch every 6 months; use a No. 6 camel's-hair brush as indicated in the chart below.

Name and Part	Lubricant	Method
Rotary armature return spring	XY switch oil	1 dip at the point where the spring rests on the frame.
Rotary armature drive pawl bearing pin.	XY switch oil	1 dip brushed into the bearing pin.

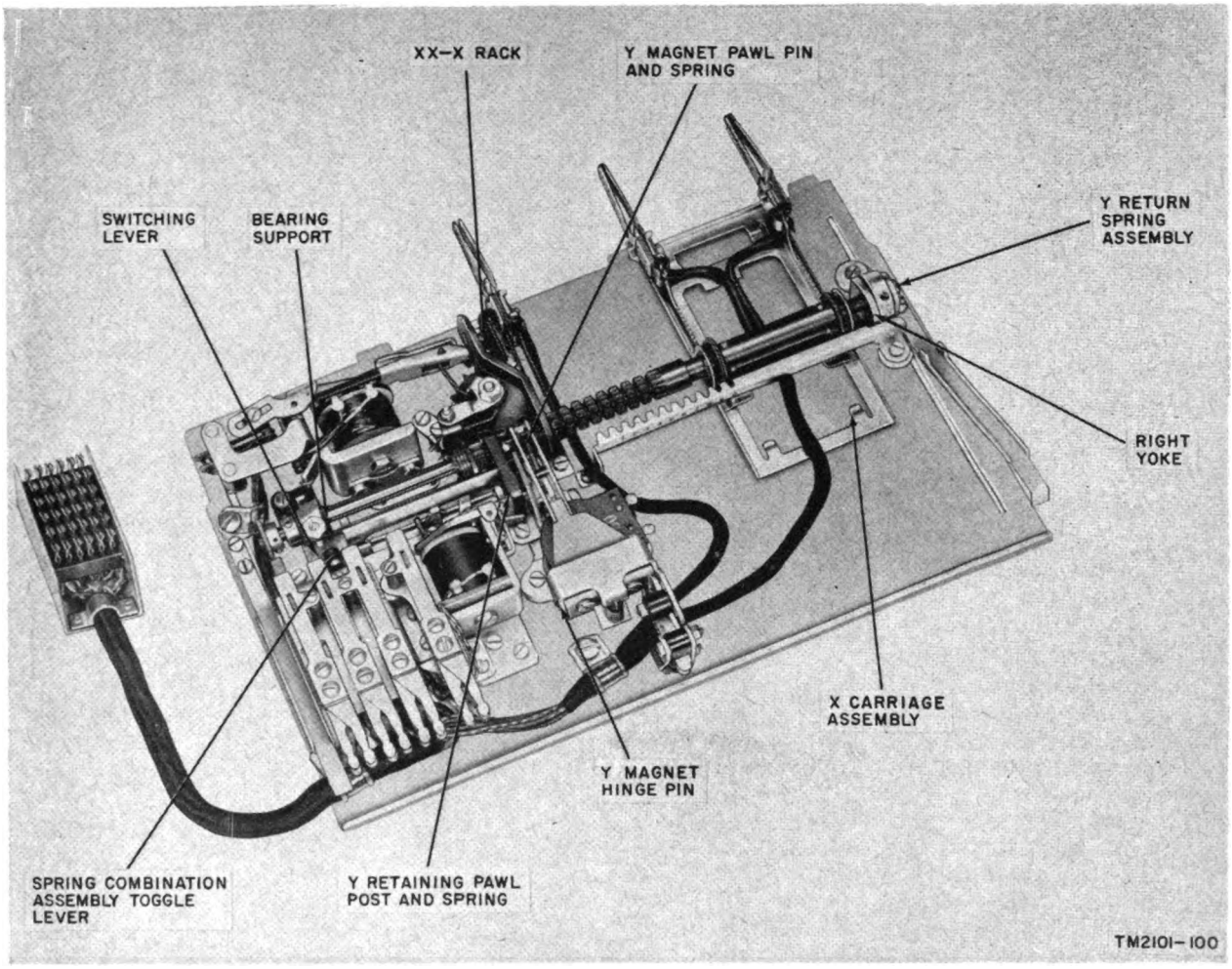


Figure 100. XY switch (off normal position), lubrication points.

Name and part	Lubricant	Method
Rotary armature bearing pin	XY switch oil	1 dip to each end of the bearing pin.
Release armature bearing pin	XY switch oil	1 dip to each end of the bearing pin.
Stop pin	XY switch oil	1 dip applied to the contact point of stop pin and release pawl return spring.
Collar	XY switch oil	1 dip to the oil slot.
Bank contacts	XY switch oil	Distribute one dip by drawing the brush across each bank level.
Plunger spring	XY switch oil	1 dip to contacting surface.
Ratchet gear	Ratchet oil	1 dip over the ratchet teeth.

200. A-Type and C-Type Relays

(fig. 103)

The A-type and C-type relays usually are not lubricated. In case of extremely heavy use, lubrication may be required annually. Lubrication under such conditions increases rather than retards bearing wear and may cause sticking and nonoperation of the relays. When lubrication is necessary, apply XY switch oil to relay bearings or bearing surfaces. One dip of oil should be sufficient for lubrication of six relays.

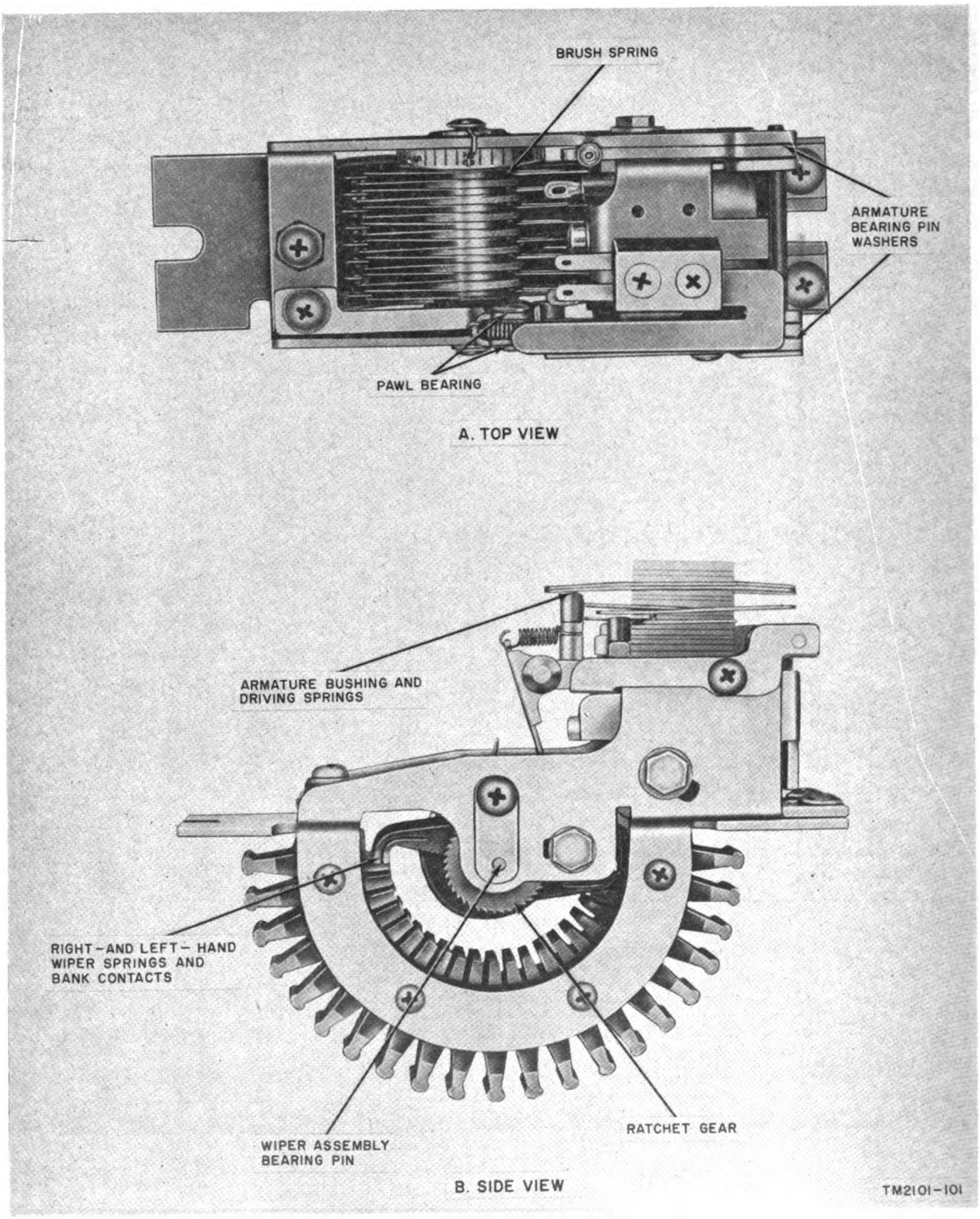


Figure 101. Rotary switch, lubrication points.

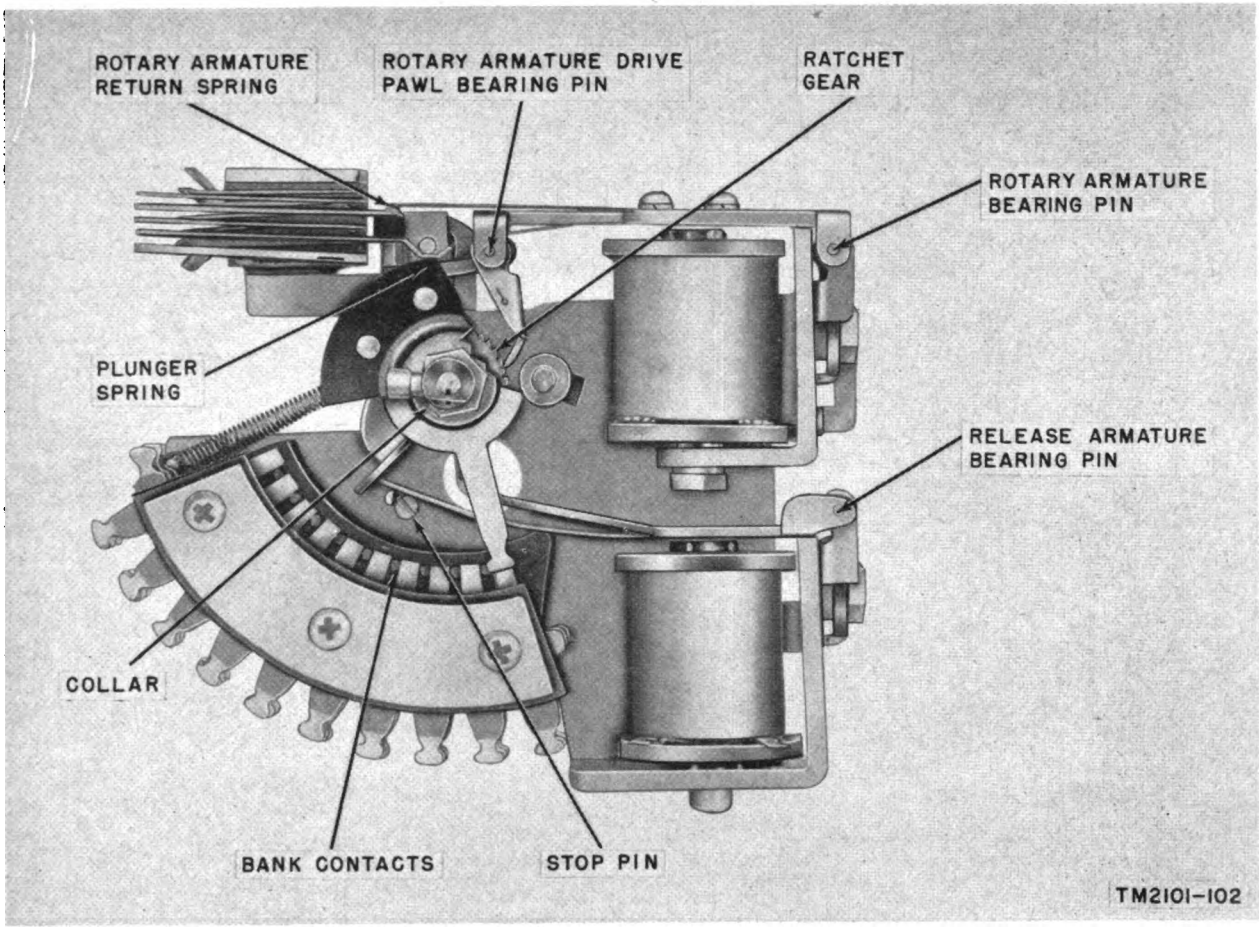


Figure 102. Minor switch, lubrication points.

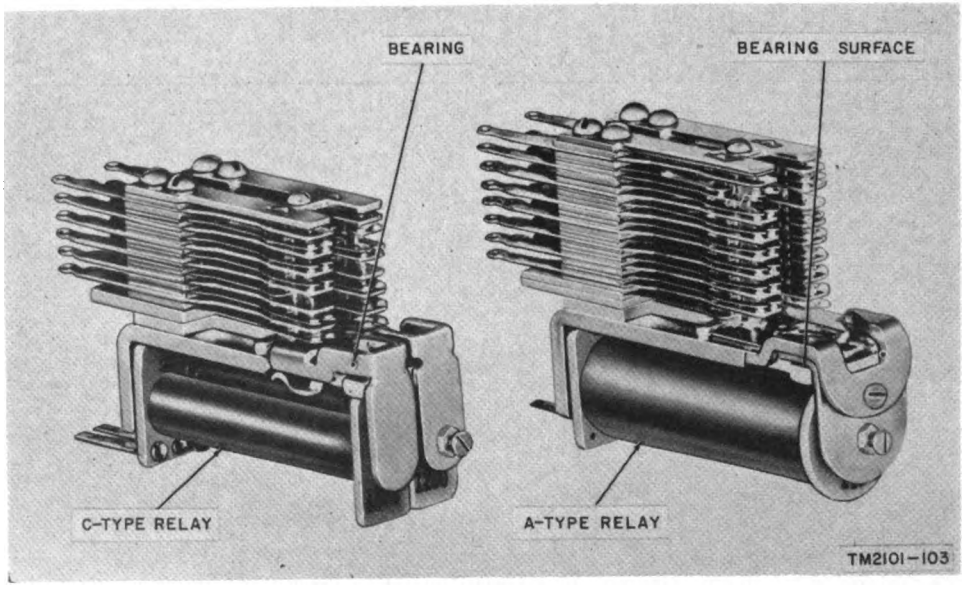


Figure 103. A- and C-type relays, lubrication points.

201. Telephone Dial (fig. 104)

a. Preparation. To prepare the telephone dial for lubrication detach it from its mounting.

(1) Remove the five terminal screws and detach the dust cover.

(2) Remove the anchor by inserting a screwdriver blade alongside the straight portion of the power spring and turning the anchor clockwise.

(3) Unscrew three screws that secure the bridge and bearing assembly, and pull it off over the power spring.

Caution: **Do not place undue strain upon the spring assemblies, because any displacement of these parts will result in improper timing of the telephone dial pulses and consequent malfunction.**

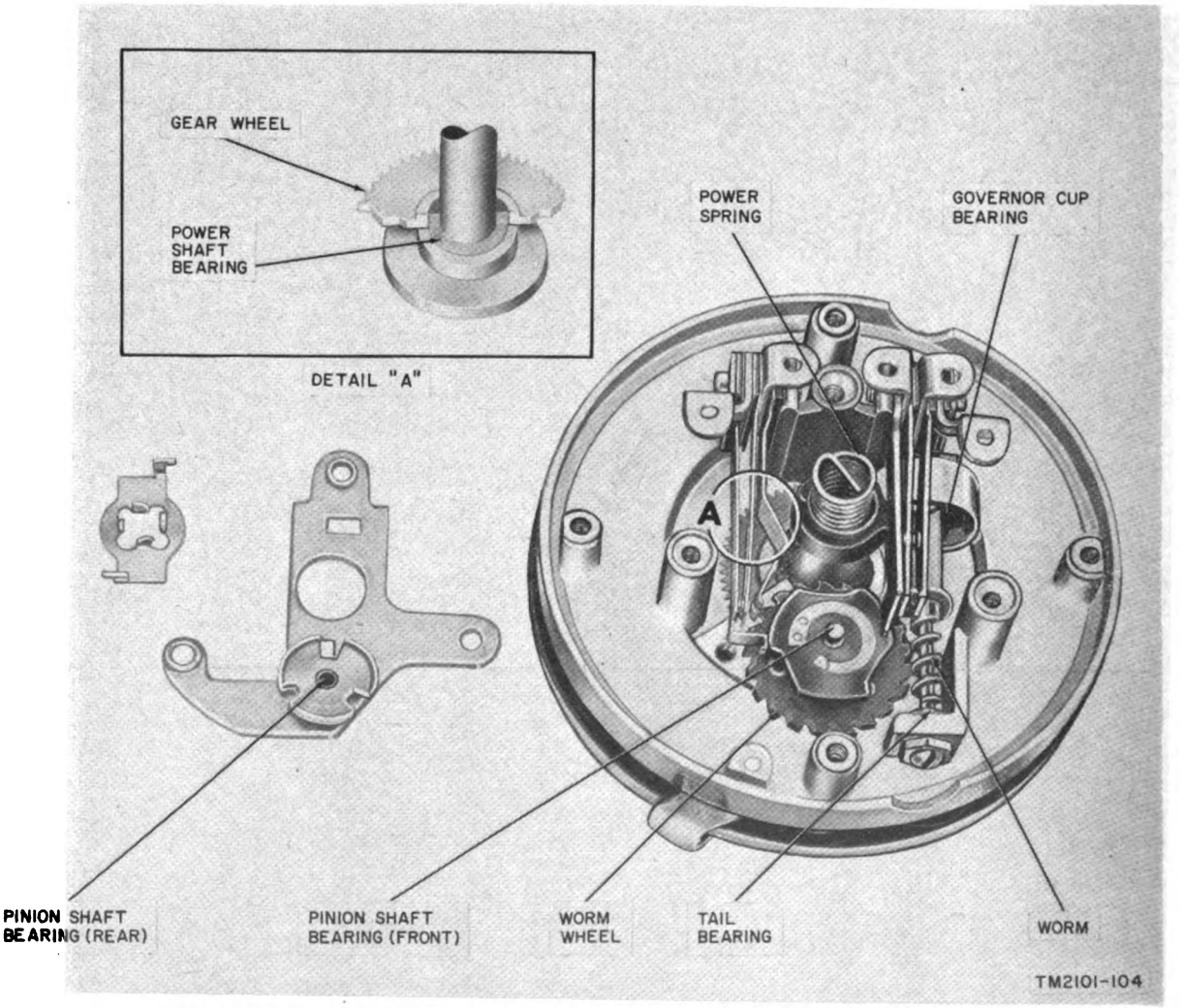


Figure 104. Telephone dial, lubrication points.

b. Lubrication.

(1) The chart below indicates the lubricating points for the dial.

Name of part	Lubricant	Method
Power shaft bearing	Dial oil (light)	Tilt the dial and allow 1 drop to flow under the gear wheel to the front bearing.
Gear wheel	Dial oil (heavy)	Brush 1 dip around the teeth of the gear wheel.
Power spring	Dial oil (heavy)	Extend the spring slightly and apply 1 dip to the exposed portion.
Governor cup bearing	Dial oil (light)	Insert the end of a wire wiped almost dry of oil to the bearing. Keep the inner surface of the cup and the fly bales free from oil.
Worm	Dial oil (light)	Distribute 1 dip evenly along the worm.
Tail bearing	Dial oil (light)	Apply 1 drop and wipe off excess oil.
Worm wheel	Dial oil (light)	Brush 1 dip around the worm wheel teeth.
Pinion shaft bearing (front)	Dial oil (light)	Lift out the pinion assembly and brush 1 dip into the front bearing.
Pinion shaft bearing (rear)	Dial oil (light)	Apply 1 dip to the cam and rear bearing.

(2) Reassemble the dial.

(3) Dial the digit 0 a few times to distribute the oil evenly.

202. Peg Count Meter (fig. 105)

The peg count meter is lubricated only if operation is sluggish or if wear is evident.

a. Remove the seal and cover.

b. Unhook the retaining strips and apply 1 dip of XY switch oil to the bearing surface at each end of the drum, switch wheel, and armature assembly spindles. One dip should be enough to lubricate all bearing surfaces.

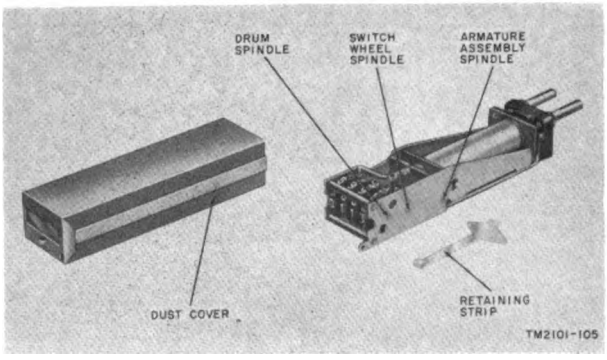


Figure 105. Peg count meter, lubrication points.

203. Push, Turn, and Lever Switches

a. Turn Switch (fig. 106). Unless the switch shows signs of excessive wear, oil should not be applied. If lubrication is necessary, brush 1 dip of XY switch oil over the accessible bearing surfaces and remove the excess.

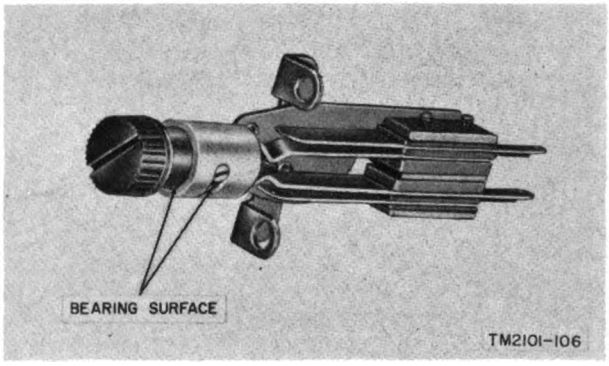


Figure 106. Turn switch, lubrication points.

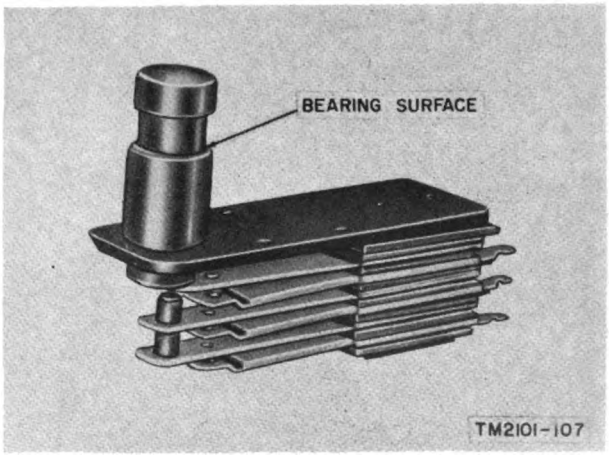


Figure 107. Push switch, lubrication points.

b. Push Switch (fig. 107). Unless the switch shows signs of excessive wear, oil should not be applied. If lubrication is necessary, apply 1 dip of XY switch oil to the exposed portion of the plunger bearing surface when the switch is inoperative. Press the button a few times and wipe off the excess.

c. Lever Switch (fig. 108). Unless the switch shows signs of excessive wear, oil should not be applied. If lubrication is necessary, apply 1 dip of XY switch oil to each end of the shaft and wipe off the excess.

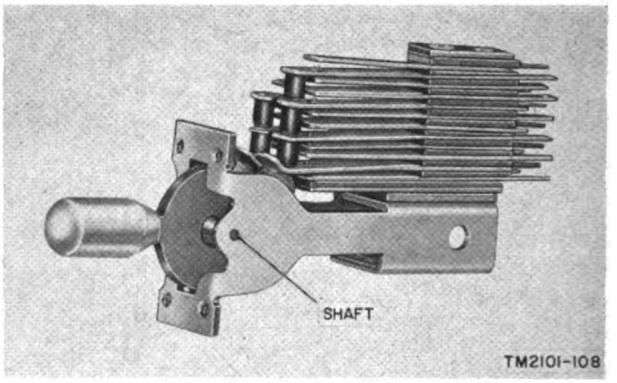


Figure 108. Lever switch, lubrication points.

INDEX

[AG 413.4 (26 Jun 58)]

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NG: State AG (6); units—same as Active Army except allowance is one copy to each unit.

USAR: None.

For explanation of abbreviations used, see AR 320-50.

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